Land contracts as a two-side occupational choice: new evidence of risk-sharing in India*

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Abstract

The importance of risk-sharing in agricultural economies has been extensively analyzed through the principal-agent framework, which predicts that sharecropping should be observed more frequently when output uncertainty is higher. However, empirical studies do not consistently show that the relation between risk and incidence of sharecropping is positive. In this paper we study the effect of risk on the distribution of land contracts in the Indian villages covered by the ICRISAT study. First, we test for the principal-agent predictions controlling for possible crop endogeneity, and find that the data reject the standard agency models. Second, we develop an econometric model based on an competitive framework. We assume landlords and tenants are 'price takers' in the market for land contracts and separately model their preferences over the contracts as an *occupational choice*. The structural estimates of the model allow to disentangle the effect of output uncertainty on the two sides of the market, after controlling for moral hazard. In this way we are able to reassess the importance of risk-sharing in determining contract choice and explain the widely observed relation between risk and incidence of share tenancy.

Keywords: risk-sharing, tenancy contracts, occupational choice, sorting.

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1 Introduction

Farming activity is usually performed under three different arrangements. Under a *wage* contract a landowner hires a tenant to work under his direction; the tenant is paid a wage rate and the landlord keeps the entire output. Under a *fixed rent* contract the tenant manages farming activity directly, keeps all output, and pays a rent to the landlord for the use of the plot. Under a *share tenancy* contract the tenant farms the plot but keeps only a portion of the final output, the remaining output going to the landlord as payment for the land use.[1]

In the last two decades several attempts have been made to explain the determinants of contract choice and the rationale for the widespread practise of share tenancy in agrarian economies. Many studies take as a starting point that farming activity is intrinsically risky and that a moral hazard problem may arise as the tenant may shirk effort, if not monitored. The effect of uncertainty on contract choice is then studied using the Principal-Agent framework, that embeds a trade-off between incentive provision and insurance by the landlord (principal) for the tenant (agent). This set up predicts that, as the uncertainty related to farming increases, the risk-sharing motive dominates the incentive one and share tenancy should be observed more frequently than fixed rent contracts, as the former partially insures the tenant.

There is, however, mixed support for this prediction. A few studies have found a negative empirical relation between crop risk and the incidence of sharecropping (Rao, 1971; Allen and Lueck, 1999), while in others share tenancy seems indeed to be associated with riskier crops (Ackerberg and Botticini, 2000). A possible explanation for these findings is that most of the empirical work is based on the assumption that crop choice is exogenous, in the sense that crop choice is entirely driven by the plot characteristics. Therefore, the riskiness of the plot can be proxied fairly well by the riskiness of the crop cultivated. However, if the crop can be chosen by the cultivator of the plot, then there may be incentives for the fixed rent tenants to choose riskier crops than share tenants. Since these incentives cannot be ruled out even within a Principal-Agent framework, the empirical observation of fixed rent contracts associated more frequently with riskier crops does not imply a rejection of the agency theory models.[2] Instead, in order to test for the principal-agent framework,

[1] The literature usually refers to the tiller hired under the wage contract as a *wage laborer*, while it uses the term *tenant* in case of sharecropping and fixed rent contracts. To simplify we always refer to the contracting parties as tenant and landlord, regardless of the land contract. In the following the terms *share tenancy* and *sharecropping* are also used interchangeably.

[2] Basu (1992) finds that a Principal-Agent model with limited liability generates a moral hazard problem in risk-

empirical work should explore the relation between contract choice and farming risk, controlling for crop choice incentives.

More generally, however, the Principal-Agent framework may be subject to criticism when used to study certain agrarian economies. A key feature of agency theory is that the tenant has no bargaining power in shaping the contract and determining the contract payments. These are set by the landlord to maximize his profit, leaving the tenant at his reservation utility. But such an asymmetric treatment of the economic power of landlords and tenants generates an exploitative relation that may not be realistic. Casual evidence on a number of agrarian societies shows that their tenants enter the agrarian contracts that best fit their needs, and that the tenant-landlord relation is far from being exploitative. As mentioned in Reid (1987), agrarian contracts are different ways to organize the management of a farm and we should not expect one theory of management to be valid over different periods and places.

The purpose of the present paper is to shed light on the determinants of contract choice and the risk-sharing role of share tenancy in an agrarian economy. Our attention is focused on the Indian villages that participated in the survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) between 1975 and 1984. In this area weather uncertainty and soil characteristics make agricultural activity highly risky compared to the rest of the country, so that there is significant scope for risk-sharing through contract choice. Our empirical strategy is first to test the predictions of the principal-agent framework allowing crop choice to be endogenous, and second to analyze the empirical relation between risk and contract choice using a theoretical approach which moves away from the asymmetric relation imposed by the Principal-Agent models.

To test the principal-agent theory, we derive different sets of predictions on the relation between contract choice and plot risk on one hand, and contract choice and crop risk on the other, under both assumptions that crop choice is exogenous and endogenous. This involves obtaining two different measures of output risk for any given plot, one related to the exogenous risk of farming a specific plot regardless of the crop planted, and the other related to the crop uncertainty. We find that in the villages studied share tenancy is more frequent than fixed rent contracts when exogenous plot uncertainty is lower, whether crop choice is considered exogenous or not. Thus the predictions of the principal-agent framework are unambiguously rejected.

taking behavior by the tenant and that tenants under fixed rent contracts engage in riskier farming techniques than share tenants.

Given the rejection of agency theory, we proceed to analyze the role of risk in contract choice using an alternative framework to agency theory, that may be more suitable for the agrarian economy under study. In a companion paper (Brancaccio, 2001) contract choice is considered as an *occupational choice*. Both tenants and landlords are allowed to choose, among a given set of contracts, the one that maximizes their utility, taking as given the associated contractual terms (or payments). Because of heterogeneity in underlying fundamentals (e.g. wealth, ability, etc.) agents self-select into specific contracts. Given the nature of the contracts, tenants and landlords decide whether to assume the cultivation risk and be "entrepreneurs", or to earn a fixed income, or to be "franchising" entrepreneurs and share the risk. The contract payments are then determined in equilibrium so that the choice of the landlord about which contract to offer is compatible with the preferences of the tenant. Hence the equilibrium displays an efficient matching of tenants and landlords with complementary characteristics. The relationship between risk and contract choice in equilibrium depends then on the elasticities of the agents' choices with respect to risk, which are functions of the agents' risk aversion.[3]

In the present paper we estimate a parameterized version of Brancaccio (2001) that captures the specific features of the Indian villages under study. The structural form proposed separately models the probabilities of landlords to offer and tenants to accept the different contracts, and it embeds both the risk-sharing features and the effort incentive problems related to the specific contracts. Hence, the structural estimates of the model allow us to: a) identify the risk-sharing mechanism after controlling for the effect of moral hazard on the individual choices, and b) disentangle the effect of output risk on the preferences of landlords and tenants. In this way it is possible to understand whether share tenancy is more frequent in less risky environments because risk-sharing is irrelevant or because such relation is the resulting 'net effect' of risk on the contract distribution that combines the effects on both sides of the land contract market.

We find that both landlords and tenants are risk averse so that there is significant scope for

[3]A similar framework could also be used to analyze housing contract choice. Home owners and hunters decide which market to enter, i.e. whether to sell/buy or rent a house, at the prevailing market prices. Heterogeneity in wealth, liquidity constraint and demographic characteristics whithin the two groups determines the demand and supply of houses in the two markets. Finally market prices adjust so that excess demands/supplies are cleared.

Note that this framework is close in spirit to the *equalizing differential* models originally developed to explain job choices and wage differentials across observationally equivalent workers. While in such models wages adjust to equalize differentials across jobs related to 'workplace amenities' so that the demand for jobs with specific characteristics equals the supply, in our context contract payments adjust to equalize the different level of risk inherent the contracts. See Rosen (1986) for a clear exposition of the theory and its applications.

them to trade and share risk through share tenancy in the ICRISAT villages. Hence, the observed negative relation between risk and incidence of share tenancy is not due to the non existence of the risk-sharing motive, but to the fact that the observed outcome is a 'reduced form' relation.

More generally this paper shows that the Principal-Agent framework may fail to capture the existing social and economic relations in some agrarian economies, and on the other side proposes a different framework that better fits the data. While the focus of the paper is on the positive economic question of contract choice, it also has a policy implication. For a long time, share tenancy has been considered the deplorable way in which landowners exploited landless tenants, and many countries have forbidden its practise.[4] However, if tenants choose the contracts they sign, and market forces efficiently select tenants and landlords in specific contractual arrangements, then it may not be welfare improving to eliminate share tenancy as it matches landlords and tenants with complementary features and compatible needs. Therefore understanding how the market for land contracts works in these villages is of crucial importance in order to decide future policies. Also, if share tenancy is indeed chosen for its risk-sharing features, then its forceful elimination in developing countries where insurance markets are absent or limited may actually worsen the welfare of those economic agents for whom the policy is intended.

The rest of the paper is structured as follows. Section 2 discusses the main weaknesses of agency theory when applied to land contracts and describes in more details the alternative theoretical model. Section 3 presents the predictions of the principal-agent framework tested in the empirical analysis, while Section 4 develops the econometric structural model. In Section 5 we describe the data and how we construct crucial variables. Finally Section 6 presents the results and Section 7 concludes.

2 Principal-agent vs. competitive analysis

2.1 Moral hazard models: theory and evidence

The first application of the principal-agent framework to the analysis of land contracts is Stiglitz (1974), which addresses the issue of moral hazard in tenants' effort. At the core of the model is the idea that if output is uncertain, the landlord cannot verify the effort provided by the tenant unless

[4] In 1955 the Indian government approved the Land Reform Act enabling registered share tenants to claim permanent and inheritable incumbency rights to the plots taken up under share tenancy, and capping the landlords' share to 25 percent. The ultimate purpose of the Act was to eradicate share tenancy.

he closely monitors farming activity. If monitoring is costly, tenant's effort has to be elicited through the structure of the contract offered, by linking his payoff to the final output. This mechanism of incentive provision, however, exposes the tenant to farming uncertainty, and if the tenant is risk averse, then it may become too costly for the landlord to provide high-powered incentive and at the same time satisfy the participation constraint of the tenant. The choice between wage contract, share tenancy and fixed rent contract is then dictated by the trade-off between incentive provision and insurance. When uncertainty increases, the risk-bearing motive becomes more important, and the landlord is more likely to switch from the fixed rent contract, which is the best incentive-wise, to a less powered contract such as share tenancy. Eventually, in extremely risky environments, it may even be optimal for the landlord to thoroughly give up on incentive provision and fully insure the tenant by offering a wage contract. This canonical set up, therefore, predicts that the incidence of share tenancy with respect to fixed rent contracts depends positively on output risk, while the probability of observing share tenancy relative to wage contracts should decrease with risk.

More recently, many efforts have been made to incorporate more realistic features of agrarian economies into this basic framework. Ghatak and Pandey (2000) study the optimal contract when there is joint moral hazard in productive effort, which affects the mean of the output distribution, and in risk-taking behavior, which affects the spread of the distribution. Such moral hazard in risk from the tenant's side is induced by the presence of the limited liability clause by which the tenant cannot be held responsible of the rent if his income (or wealth) at the end of the cropping season is below some threshold. Such clause makes the tenant act as a risk-lover agent and induces a form of moral hazard in risk-taking behavior, such as choice of crops, use of fertilizer and water resources, and more general farming decision making.[5] The main results of their study are that: a) the wage contract is never offered by the landlord, and b) share tenancy is more likely to be observed over fixed rent contracts if moral hazard in risk is more severe than moral hazard in effort. The intuition is that even though the wage contract eliminates the moral hazard in risk, it has a severe incentive problem. Hence the share tenancy contract is always better than a wage contract, as the resulting increase in effort dominates the increase in risk. Between share tenancy and fixed rent contract, the choice is dictated by the relative importance of the two types of moral hazard. If moral hazard in risk is relatively more severe, then the landlord finds optimal to discourage risk-taking behavior through share tenancy at the cost of reducing incentive on effort. The key point therefore is that

[5] Basu (1992) first studied the effect of limited liability on the optimal contract.

if moral hazard in risk is present, riskier farming techniques would be associated with fixed rent contracts.

The empirical literature on sharecropping focused on the relation between risk and contract choice in order to test the main predictions of the principal-agent model with moral hazard. In Rao (1971) and Allen and Lueck (1992, 1995, 1999) very different contemporaneous agrarian economies (semi-arid Indian villages and North-American farms respectively) are studied and the results show that sharecropping is more frequently observed than fixed rent contracts when less risky crops are cultivated. Under the hypothesis that crops planted are exogenously determined, the authors conclude that share tenancy is more commonly chosen in less risky environments, contrary to the theoretical prediction. In Ackerberg and Botticini (2000), where attention is focused on historical Italian data, riskier crops are instead found to be more likely observed under sharecropping.

Ackerberg and Botticini (2001) attempt to reconcile these empirical results with the theoretical predictions by arguing that the econometric specifications may suffer from endogeneity bias due to the agents' matching and the intertwining of the moral hazard and risk-sharing motives. Given that in a moral hazard framework there may be incentives for heterogeneous tenants to match with particular landlords, correlation in personal characteristics may cause biased estimates if some characteristic is partially observed or poorly proxied, so that the true effect of risk on contract choice may be obscured by incentive on matching. They approach the problem by proposing a reduced form matching equation to estimate jointly with a contract choice equation and find evidence that *less risk averse tenants are more likely to accept fixed rent contracts*, hence concluding that there are significant incentives on matching based on agents' attitude towards risk. However, even after controlling for endogenous matching, they find that *the effect of cultivation risk on the type of contract offered by the landlords* may or may not be significant depending on the instruments set and functional forms used, so that again there is no strong evidence in favor or against the principal-agent model predictions.

A problem common to all the empirical papers cited, however, is the maintained assumption that crop choice is exogenous, so that riskiness of the crop cultivated on a specific plot is an adequate measure of exogenous uncertainty. But if the crop planted is chosen by the farmer, then a result such as the one found by Allen and Lueck does not necessarily contradict the principal-agent model. It may instead be compatible with a principal-agent framework with joint moral hazard in effort and risk, where fixed rent contracts are indeed associated with riskier farming techniques, such as the crop planted.

Different in flavor, the work by DeWeaver and Roumasset (2001) calibrates and simulates a principal-agent model with moral-hazard in effort using Philippines data. They show that the model fails to replicate the observed distribution of contracts, and hence conclude that "the canonical theory is rejected at the 0% significance level" (page 19).

Even though the existing empirical evidence cannot conclusively refute the principal-agent framework, doubts arise on its adequacy for describing modern agrarian economies. One of the key aspects of the principal-agent set up is that even if landlords are heterogeneous and offer different contracts, these are always utility equivalent for the tenants to their outside option, since the tenant's participation constraint is typically binding. Hence, if in equilibrium contracts generate a surplus, this is gained exclusively by the landlords, and tenants are left with their reservation utility. This may seem to be driven by a perfectly elastic supply of tenants. However, as argued in Bell (1989), this is not enough. Even if the supply of tenants is large compared to landlords, tenants can still have bargaining power in sharing the surplus if their refusal can 'hurt' the landlord. If landlords have outside options and incur an opportunity cost when meeting tenants, then a refusal can indeed be harmful and landlords may find it profitable to raise the offer to attract the tenant. Similarly if tenants are heterogeneous in working ability, landlords may prefer to raise the offer to avoid refusals from more skilled tenants. In either circumstances the tenants hold bargaining power that could help them obtain part of the surplus.

The question is therefore in which situations the asymmetric position assigned to landlords and tenants by the principal-agent framework is a reasonable assumption. For medieval agrarian economies, such as the one studied by Ackerberg and Botticini, the relation between landless peasants and wealthy landlords might realistically be described as exploitative; but in modern societies it may be difficult to think that contracts are imposed on tenants. To restrict our attention to the case studied in this paper, casual evidence on the tenancy relation in contemporary Indian villages shows that tenants seem to enter the type of contract that best fits their personal characteristics and economic status. Sharma and Drèze (1996) describe the tenancy relationship in the North Indian village of Palanpur as a "partnership involving both conflict and cooperation", far from the exploitative stereotype. Furthermore, they show that tenants and landlords have on average the same wealth and income. Jodha (1981) finds that during the late '70s in the ICRISAT villages tenants were usually large farmers while landowners offering their land through tenurial contracts were operating on smaller scales, which "contradicts the conventional presumption, where the tenant is usually thought of as a poor and small operator while the landlord is believed to be invariably a large farmer (p.128)." Finally four of the six ICRISAT villages studied here were under the individual-based revenue collection system (*raiyatwari*) during the British rule in India. Under such system the land revenues were collected directly from the cultivator of the land, who had a legal title to it. So even though tenants did not have formal ownership rights to the land, the revenue system recognized their "actual control rights." This supports the idea that in the ICRISAT villages studied hereby tenants did held economic power during the British rule and most likely have maintained it after the Independence.[6]

2.2 A competitive framework

The model proposed in Brancaccio (2001) captures these important aspects and models both tenants and landlords preferences towards contracts, leaving market forces to determine the equilibrium payments.[7] In this section we outline the model and its main implications.

Farming can take place under three different contractual forms: wage contract, share tenancy contract and fixed rent contract. Landlords and tenants consider the payments associated with each of these contracts as given and respectively offer and look for the contract they prefer. In this sense agents are *price takers*, and payments are not individual specific. Tenants' outside option consists in wage labor in the urban sector.[8] Landlords' outside option is a non-farming activity. Under a wage contract, and to a lesser extent share tenancy, the landlord has to devote time to attend cultivation and monitor so that he incurs an opportunity cost in terms of foregone earnings, or *monitoring cost*.

[6] In other areas, such as Bengal, the British rule imposed the *zamindari* or landlord-based system, where the landlowners were in charge of revenue collection and tenants had no legal recognition. The other two ICRISAT villages studied in this paper apparently did not belong to any of these revenue systems. They were not directly under the British rule, but were part of the Nizam of Hyderabad's territory. We are grateful to Lakshmi Iyer who provided these information. In Banerjee and Iyer (2001), they study the effect of the land revenue systems imposed by the British rule on the contemporary agrarian performance of different districts in India.

[7] Another departure from the principal-agent framework is found in Bell and Zusman (1976) where contract choice is studied through a bargaining model.

[8] The presence of a nearby town or city ties down the wage in the agricultural sector because if the wage was lower than the one offered in the urban sector, discounted by migration disutility, then farmers would prefer to abandon the villages and work in the urban sector.

Tenants are heterogeneous in their farming (or managerial) ability so that more skilled tenants are able to obtain higher output under share tenancy and fixed rent contracts than low skilled tenants. Landlords are heterogeneous with respect to their opportunity cost (or monitoring technology); landlords with good alternative business opportunities typically have a higher opportunity cost if they have to attend cultivation closely, or alternatively some landlords may be particularly bad at supervising labor so that their cost is higher.[9] Given such heterogeneity in farming skills and monitoring cost, tenants and landlords may have different preferences towards the contracts for given associated payments. Tenants with high farming ability may prefer the fixed rent contract to the wage and share tenancy contract since it allows them to keep the whole output and, therefore, accrue the returns to their skills. On the contrary, unskilled tenants will prefer the wage contract where their remuneration does not depend on their farming (in)ability. Similarly landlords with very high opportunity cost prefer a fixed rent contract as it frees them from any involvement in cultivation and allows them to attend other activities, while landlords with poor outside opportunities choose the wage contract. Share tenancy is then a way to match the preferences of tenants and landlords with intermediate farming skills and monitoring cost. The selection of tenants and landlords in the different contracts conditional on the wage rate, the output share and the rent determines the demand and supply of each contract.

Note that even though the present paper moves away from agency theory, it does not ignore the central issue of moral hazard, as we assume the presence of monitoring cost. We also account for possible moral hazard in effort devoted for the maintenance of the plot. When agrarian contracts are for short terms, the tenant has virtually no incentives in investing effort and resources for the maintenance of the plot, which may in turn result in decreased fertility. Hence we assume that under share tenancy and fixed rent contracts, the landlords incur a *multitasking*-moral hazard cost.

Market equilibrium imposes that the payments have to adjust so that the offer of a specific contract from landlords equals the demand from tenants. For example an increase in the rent makes the fixed rent contract more attractive for landlords compared to share tenancy and wage contract, so that some landlords may switch, but it also makes the fixed rent contract less attractive for tenants who might therefore decide to prefer share tenancy or wage contract.

[9] Eswaran and Kotwal (1985) also exploit the idea that the optimal contract may depend on the relative skills of the agents in supervising and managing the land. Though the qualitative prediction is close in spirit, the present model provides a radically different framework, as they analyze a one-to-one principal-agent relation.

The framework outlined above has two particularly interesting features. First, as in a standard demand-supply framework, both tenants and landlords enjoy a surplus unless they are the marginal agents. The marginal agents are, in fact, defined as the tenants and landlords who are indifferent between the contracts given the equilibrium payments, so that any agent who strictly prefers one contract over the others, conditional on the payments, is gaining an economic rent. Second, this set up has the potential to predict that sharecropping is less frequent than the fixed rent contract when output risk is higher and the only driving force is risk-sharing. When cultivation becomes riskier, the demand and supply of each contract change according to the preferences of the agents. More specifically if tenants are risk averse, then their demand for share tenancy contracts relative to fixed rent contracts increases because of the risk-sharing feature of sharecropping. On the contrary risk-averse landlords decrease their supply of share tenancy relative to fixed rent contracts. Higher uncertainty may therefore be associated in equilibrium with a higher or lower ratio of share tenancy to fixed rent contracts, depending on the elasticities of the relative demand and supply with respect to risk. Similarly higher risk can generate in equilibrium a higher or lower frequency of wage contracts with respect to share tenancy. Such elasticities depend on the structure and the primitives of the model, and in particular on the relative degree of risk aversion of landlords and tenants.

Note that in equilibrium the contractual terms constitute a price mechanism that efficiently matches the most compatible landlords and tenants. Landlords with low opportunity cost offer wage contracts and are matched with low skilled tenants demanding such contracts, and similarly high (intermediate) opportunity cost landlords are matched with high (intermediate) ability tenants under fixed rent contracts (share tenancy). The matching process clearly generates ex-post correlation in the characteristics of the agents matched, but as we separately model the decision process of landlords and tenants, the structure of the matching is fully characterized and endogeneity is not an issue. The *positive sorting* displayed in equilibrium has characteristics similar to the sorting that arises in equalizing differential models, where workers with stronger preferences for certain job characteristics end up matching with firms providing jobs with those features. In our case the tenants' and landlords' decisions about which contract to accept and offer can be seen as an occupational choice in which agents choose among three different income distributions, and the differential equalized in equilibrium is related to the different risk inherent to such distributions.

Finally, the assumption that all agents are *price takers* may seem questionable since landlords offer contracts and set the contractual terms, as argued by Singh (1989). The main point of this model, however, is that though landlords offer contracts and set the payments, they must compete for the tenants, i.e. they have to set payments so that there are tenants willing to accept the contract they offer at those terms. Such competitive pressure drives to zero excess demand/supply of the different contracts. It is therefore a long run theory of equilibrium in the tenancy market, while it is silent about how agents search for the best option and how the equilibrium is reached. Price-taking behavior might also explain why contract payments do not seem to be individual specific in many agrarian economies. Output is usually split according to the 50-50 rule under share tenancy, regardless of personal characteristics of landlords and tenants; an empirical puzzle that cannot be explained through a principal-agent framework with heterogeneous actors.

3 Testing the principal-agent model

Before turning to the estimates of the structural model, we estimate the type of multinomial reduced form logistic model used previously in the literature to test the Principal-Agent framework. The purpose of this analysis is to investigate whether the lack of empirical support for the agency theory is the result of using inappropriate measures of risk, that do not take into account possible endogeneity of crop choice.

The crucial point is to construct two different measures of output risk for each plot. The first measure is obtained as the output variability of the plot given its characteristics, such as soil type and location, and it should therefore pick up the exogenous cultivation risk inherent in the plots, regardless of the crop planted. The other measure of risk is instead obtained as the output variability of the crop planted on a specific plot; therefore, it captures crop-related uncertainty and it is in line with the measures of risk used in other empirical works.

The predictions of the principal-agent model tested in the empirical analysis are:

Case 1 *If crop choice is exogenous, then:*

a) the two measures of risk are highly correlated;

b) the incidence of wage contract relative to share tenancy increases with risk, and so does the incidence of share tenancy relative to fixed rent contracts, regardless of which risk measure is used.

Case 2 *If crop choice is endogenous, then:*

a') the two measures of risk may not be correlated;

b') the incidence of share tenancy relative to fixed rent contracts decreases when the crop-related risk increases, and decreases when the exogenous risk increases.

The rationale underlying these predictions is that if the crop planted is exogenously determined, then certain crops are more likely planted on plots with specific characteristics; hence, the two measures of risk should be correlated in response to the correlation between plot characteristics and crops planted. Furthermore, in this case there is no role for risk-taking behavior through crop choice by the tenant, while moral hazard in effort may be severe. Therefore, we would expect share tenancy to be more frequently observed than fixed rent contracts and less frequently observed than wage contracts when exogenous plot-related risk is higher, as in the canonical principal-agent model *a' la* Stiglitz. As crop planted is determined by plot characteristics, crop risk also measures an exogenous form of uncertainty, so that we would expect to find similar relations between contract choice and crop-related risk.

On the other side, if crop planted is endogenous, i.e. chosen by the tenant, then the two risk measures are not necessarily correlated. Due to moral hazard in effort we should still observe that share tenancy is more frequently observed than fixed rent contracts on exogenously riskier plots. But if moral hazard in risk-taking behavior is also present, due to limited liability, then we also would expect to find fixed rent contracts to be associated with riskier crops, while under share tenancy safer crops prevail. Hence crop-related risk should have an independent effect (and of opposite sign) from the exogenous measure of risk on the type of contract.

To test the predictions under Case 1, we estimate a multinomial model of contract choice controlling first for exogenous plot-related risk, and then for crop-related uncertainty. If the principal-agent framework is valid then we should expect the two measures of risk to have a positive effect on the probability of observing wage contracts relative to share tenancy, and a negative effect on the probability of observing fixed rent contracts relative to share tenancy. To test the predictions under Case 2, we estimate a logit model of choice between fixed rent contracts and share tenancy where we control for exogenous risk and crop-related uncertainty simultaneously as opposed to Case 1. If the principal-agent framework is valid then we would expect the exogenous risk to have a negative effect on the probability of observing fixed rent relative to share tenancy due to moral hazard in effort, and the crop-related risk to have a positive effect due to moral hazard in risk. Results are shown in Section 6.2.

4 The econometric specification of the competitive model

In the present section we develop the structural econometric model based on the competitive framework described in Section 2.2. We first model the output function and the utilities obtained by a generic tenant i and a landlord j from the three different contracts, and derive the structural multinomial models describing their individual choices. Based on the assumption that the economy is in equilibrium, we then formulate the likelihood function. In defining the structure of the model we keep in mind the characteristics of the Indian villages whose data will be used for estimation; hence such a structural model might be unsuited to describe other economies.

a) Output

Output on a plot p at time t (Y_{pt}) is assumed to be produced by a Cobb–Douglas function of land (h_{pt}), labor (ℓ_{pt}) and capital (K_{pt}) while plot characteristics (Z_{pt}) enter as shift parameters. The error term (u) is assumed to enter the output function additively and it includes a time-independent individual effect representing the farming skills of the agent cultivating the plot (η), a time effect capturing possible correlation in output across plots due to similar weather conditions (ρ), and an idiosyncratic component independent across time and individuals capturing plot specific uncertainty (v).[10]

As under a wage contract the landlord cultivates the land, while under share tenancy and fixed rent contract the tenant manages it, input choices are made by the landlord j and the tenant i in the respective cases. Similarly the relevant individual farming skills are the ones of the landlord j if the plot is managed under a wage contract, and of the tenant i if the plot is taken under fixed rent contract or share tenancy. Hence the final output under contract c is given by

$$Y_{pt}^{c} = \begin{cases} \left(\ell_{jpt}^{c}\right)^{\theta} (h_{pt})^{\pi} \left(K_{jpt}^{c}\right)^{\varphi} \exp(\phi Z_{pt}) + u_{jpt} \text{ if } c = W \\ \left(\ell_{ipt}^{c}\right)^{\theta} (h_{pt})^{\pi} \left(K_{ipt}^{c}\right)^{\varphi} \exp(\phi Z_{pt}) + u_{ipt} \text{ if } c = S, F \end{cases} \tag{1}$$

$$\text{with } \begin{cases} u_{jpt} = \eta_j + \rho_t + v_{pt} \\ u_{ipt} = \eta_i + \rho_t + v_{pt} \end{cases}$$

where W indicates the wage contract, S the share tenancy contract, and F the fixed rent contract. All components of the error term are assumed to have zero mean. To focus on tenants' heterogeneity

[10] Additive uncertainty is important in our framework since it allows us to compare the utilities under each contract for a given agent by using mean-variance analysis without having cumbersome expressions. Such an assumption is also made in Laffont and Matoussi (1995).

with respect to farming skills and landlords' heterogeneity with respect to opportunity cost, we assume that $\sigma^2_{\eta_j} = 0$, and that therefore the variance of the individual effect is due to farming skills variation across tenants. The time effect and the random component have variances equal to σ^2_ρ and σ^2_v respectively with, $cov(\rho_t v_{pt}) = 0$.

b) Contracts and input choices

Under the wage and the fixed rent contract, the landlord and the tenant respectively accrue the whole output and bear the full cost of all inputs. In both cases therefore inputs are chosen by equating their marginal product to their cost. Under share tenancy, the tenant accrues only a portion α_t of the final output, and while for some inputs he bears their full cost, the cost of other inputs is shared with the landlord. Input intensities are then decided by equating the marginal product the tenant accrues with the portion of marginal cost he bears. Inputs whose cost is fully borne by the tenant are typically underprovided.[11] This implies that input intensities are endogenous with respect to the contract form and we need to obtain demand functions for each input (labor and capital) under each contract, and use 'indirect' production functions conditional on the efficient choice of all inputs given the contract type. However, explicitly considering the demand functions of all inputs makes the econometric specification quite intractable. Also, while labor input is always provided exclusively by the tenant under share tenancy, capital input may actually include some forms of capital whose cost is shared between landlords and tenants, and some forms whose cost is fully borne by the tenants.[12]

To reduce the complexity of the structural form and to allow flexibility in terms of cost sharing rules for the different forms of capital, we use the following specification of the production function

$$Y^c_{pt} = \begin{cases} \left(\ell^c_{pt}\right)^{\theta'} (h_{pt})^{\pi'} \exp(\beta_1 Z_{pt}) + u_{pt} \text{ if } c = W, F \\ \left(\ell^c_{pt}\right)^{\theta'} (h_{pt})^{\pi'} \exp(\beta'_1 Z_{pt}) + u_{pt} \text{ if } c = S \end{cases} \tag{2}$$

which is derived from eq.(1) after substituting the contract-specific optimal demand function for capital and where individual subscripts are omitted for simplicity. In Appendix A, we show the relation between the parameters in eq.(1) and in eq.(2). The optimal labor demand functions used

[11] This result is known in the literature as the *Marshallian inefficiency* of share tenancy.

[12] A second level of endogeneity might affect eq.(2) if agents face individual-specific input and/or output prices. We rule out this possibility and instead assume that in a specific period t within a village all agents face the same prices.

for the remaining analysis are

$$\ell_{jpt}^{W} = \ell_{ipt}^{F} = \left(\frac{1}{w_t} \theta' \left(h_{pt} \right)^{\pi'} \exp(\beta_1 Z_{pt}) \right)^{\frac{1}{1-\theta'}} \tag{3}$$

$$\ell_{ipt}^{S} = \left(\alpha_t \frac{1}{w_t} \theta' \left(h_{pt} \right)^{\pi'} \exp(\beta_1' Z_{pt}) \right)^{\frac{1}{1-\theta'}} . \tag{4}$$

b) Utilities

Landlords and tenants are risk averse. Utility functions are exponential, implying that the absolute risk aversion coefficient is constant. Formally

$$u_{it}(I) = -\frac{1}{\gamma_1} e^{-\gamma_1 I} \tag{5}$$

$$u_{jt}(I) = -\frac{1}{\gamma_2} e^{-\gamma_2 I} \tag{6}$$

where I denotes the level of income, $u_{it}(I)$ and $u_{jt}(I)$ are the utility functions of a tenant i and a landlord j at time t respectively, and γ_1 and γ_2 are their Arrow-Pratt measures of absolute risk aversion.[13]

We turn now to the specification of the expected utilities under each contract where the expectation operator is denoted E. The total salary paid to the tenant for a season under a wage contract is w_t; α_t is the share of output accrued by the tenant under share tenancy; and finally R_{pt} is the rent paid by the tenant under a fixed rent contract for the plot p at time t. Such contract payments are considered exogenous by the agents when they make their decision as in any competitive model, but they are clearly determined endogenously in equilibrium. However, payments are not individual-specific in the sense that if two tenants sign the same type of contract on two plots of land with same characteristics (h_{pt}, Z_{pt}), then the contract payments are equal even if the tenants have different unobservable farming skills. Hence the wage rate, the output share and the base rent are only time-specific. To simplify notation (and given that we actually do not observe the base rent in the data available) we describe the model in terms of total rent paid R_{pt} for a plot of characteristics (h_{pt}, Z_{pt}).

[13] Note that the coefficients of absolute risk aversion may be different for tenants and landlords ($\gamma_1 \neq \gamma_2$), but there is no heterogeneity in attitude towards risk within the groups of tenants and landlords.

For tenant i the utility value attained under each type of contract is

$$V_{it}^{c}=\begin{cases} u_{it}\left(w_t\right) \text{ if } c=W \\ Eu_{it}\left[\alpha_t\left(\left(\ell_{ipt}^{S}\right)^{\theta'}\left(h_{pt}\right)^{\pi'}\exp(\beta_1' Z_{pt})+\eta_i+\varepsilon_{pt}\right)-w_t\ell_{ipt}^{S}\right] \text{ if } c=S \\ Eu_{it}\left[\left(\ell_{ipt}^{F}\right)^{\theta'}\left(h_{pt}\right)^{\pi'}\exp(\beta_1 Z_{pt})+\eta_i+\varepsilon_{pt}-w_t\ell_{ipt}^{F}-R_{pt}\right] \text{ if } c=F \end{cases} \tag{7}$$

where the expectation is taken with respect to $\varepsilon_{pt}=\rho_t+v_{pt}$. Under the wage contract the tenant simply gets his salary. Under share tenancy the tenant accrues his share of output and bears the cost of labor. Finally under the fixed rent contract he gets the total output, bears the labor cost and pays the rent. To provide labor the tenant has two options: he can either provide the labor himself (eventually having family members cultivating the land), or hire workers. In both cases the marginal cost of labor is the salary rate w_t, which can be interpreted as the value of the tenant's disutility if working himself.

We now define the utilities of a landlord j under the three arrangements. Under wage contract and share tenancy the landlord incurs an opportunity cost in terms of foregone earnings due to *monitoring*. Such cost arises because output is uncertain so that the tenant may shirk his effort under the wage contract, or underreport output under share tenancy. To avoid this the landlord has to supervise farming activity.[14] Furthermore under sharecropping and fixed rent contract the tenant has to decide how to allocate time and effort between production activity, whose return is the final output, and maintenance activity. If tenurial contracts are signed only for one or two cropping seasons, then the tenant has no incentive in maintaining the plot. In our villages contracts are signed for short term, so the landlord incurs a *multitasking cost* under share tenancy and fixed rent contracts, that can be interpreted as a decrease in the productive value of the plot due to lack of maintenance.

Let $M_{jpt}=\beta_2 Z_{pt}+\mu_j$ be the monitoring cost of landlord j at time t as a linear function of the characteristics of the plot Z_{pt} and of unobservable time-invariant personal characteristics affecting his opportunity cost μ_j, which is distributed across landlords with mean zero and variance σ_μ^2. While such monitoring cost is fully incurred under a wage contract, the landlords bears only a

[14] The underlying hypothesis is that labor effort is not enforceable ex-post under any contract type, in the sense that due to uncertainty the landlord cannot condition the tenant's reward/punishment on the final output. The landlord can reduce shirking or cheating behavior by the tenant with monitoring activity, but cannot enforce the efficient level of input intensities under share tenancy. In the villages we study, in fact, landlords cannot interfere with tenants' decisions under share tenancy.

portion $\delta \in (0,1)$ of such cost under sharecropping, as in this case he is only partly involved in farming.[15] The multitasking cost M'_{pt} is assumed to be a linear function of plot characteristics Z_{pt} and we assume that the landlord bears it equally under share tenancy and fixed rent contracts.[16] For a landlord j the utility value attained under each type of contract is

$$V_{jt}^{c} = \begin{cases} Eu_{jt}\left[\left(\ell_{jpt}^{W}\right)^{\theta'}(h_{pt})^{\pi'}\exp(\beta_1 Z_{pt}) + \eta_j + \varepsilon_{pt} - w_t \ell_{jpt}^{W} - M_{jpt}\right] \text{ if } c = W \\ Eu_{jt}\left[(1-\alpha_t)\left(\left(\ell_{ipt}^{S}\right)^{\theta'}(h_{pt})^{\pi'}\exp(\beta'_1 Z_{pt}) + \eta_i + \varepsilon_{pt}\right) - \delta M_{jpt} - M'_{pt}\right] \text{ if } c = S \\ u_{jt}\left[R_{pt} - M'_{pt}\right] \text{ if } c = F. \end{cases} \quad (8)$$

If the tenants' skills are private information, this constitutes an added source of uncertainty for the landlord under sharecropping. Therefore the expectation is taken with respect to ε_{pt} and η_i.

4.1 Individual choices

In an occupational choice setting the choice of tenants and landlords between the three contracts available can be represented as a multinomial model. The three contracts represent the three categories of an unordered variable. Let I_{it} and I_{jt} be the indicator variables representing the choice of tenant i and landlord j respectively at time t among the available contracts $\{W, S, F\}$. Then the probability for the tenant to choose one contract over the others is

$$\Pr\left(\mathrm{I}_{it} = c | Z_{pt}, \Bbbk_{pt}, \sigma_{\varepsilon}^{2}, \eta_i\right) = \Pr\left(V_{it}^{c} \geqslant V_{it}^{c'} | Z_{pt}, \Bbbk_{pt}, \sigma_{\varepsilon}^{2}, \eta_i\right) \ \forall c' \neq c \quad (9)$$

and similarly for the landlord

$$\Pr\left(\mathrm{I}_{jt} = c | Z_{pt}, \Bbbk_{pt}, \sigma_{\varepsilon}^{2}, \widetilde{\sigma}_{\eta}^{2}, \widetilde{\eta}, \mu_j\right) = \Pr\left(V_{jt}^{c} \geqslant V_{jt}^{c'} | Z_{pt}, \Bbbk_{pt}, \sigma_{\varepsilon}^{2}, \widetilde{\sigma}_{\eta}^{2}, \widetilde{\eta}, \mu_j\right) \ \forall c' \neq c \quad (10)$$

where such probabilities are conditional on plot characteristics Z_{pt}, the vector of contract payments $\Bbbk_{pt} = (w_t, \alpha_t, R_{pt})$, output risk σ_{ε}^{2} and the individual specific unobservable characteristics. For the landlords these probabilities are also conditional on the variance of the tenants' skills given the

[15] This formulation is flexible enough to incorporate the phenomenon of *absentee landlordism*. Some landlords have business in towns far from the villages where land is located; hence they establish their residence in the town and leave the management of their estates to tenants under fixed rent contracts. In our framework such landlords would have very high monitoring/opportunity cost μ_j.

[16] The multitasking cost assumed here is somewhat different from the 'land mining' hypothesis explored in Dubois (2000). There the optimal contract choice is analyzed when cultivation intensity affects land fertility and landlords can offer only short term contracts. In such case it is optimal for the landlord to offer share tenancy instead of a fixed rent contract because the former mitigates the tenant's incentive to exploit the land, implying that the exploitation cost would be higher under fixed rent contract than under share tenancy. In our model multitasking is associated with the lack of maintenance of valuable assets related to the plot and not soil exploitation, hence the cost is incurred by the landlord equally under the two contracts.

pool of tenants that have chosen sharecropping $\widetilde{\sigma}_{\eta}^{2} = E\left(\left(\eta_i^2\right)|\mathrm{I}_{it} = S\right)$, and the average skills' level of the tenants choosing share tenancy $\widetilde{\eta} = E\left(\eta_i|\mathrm{I}_{it} = S\right)$.

Given the definitions of compensating risk premium and equivalent risk premium as formulated by Pratt (1964), we can obtain thresholds for the unobservables η_i and μ_j such that the inequalities in eqs.(9)-(10) are satisfied.[17]

4.2 Equilibrium matching and the likelihood function

In equilibrium contract payments adjust so that both landlords and tenants sign the contract they prefer. Hence if the economy is in equilibrium the possibility of a mismatch, meaning that a tenant or a landlord sign a contract different from his first best, given his characteristics, is ruled out, and the observation of a specific contract between a landlord and a tenant 'reveals' that: a) they both prefer the observed contract to the other possible contracts, given their matching and contract payments; and b) they prefer the observed matching to all other possible matching. Note also that landlords and tenants independently make their choices conditional on contract payments and self-select into specific contracts and matchings. Therefore, the probability of observing a contract on a specific plot is given by the joint probability that the tenant and the landlord have chosen it, and due to the structure of the model the joint probability is the product of the marginal probabilities. The likelihood of observing plot p at time t under contract c is given by

$$\pounds_{pt}^{c} = \Pr\left(\mathrm{I}_{it} = c|Z_{pt}, \mathbb{k}_{pt}, \sigma_{\varepsilon}^{2}, \eta_i\right) \cdot \Pr\left(\mathrm{I}_{jt} = c|Z_{pt}, \mathbb{k}_{pt}, \sigma_{\varepsilon}^{2}, \widetilde{\sigma}_{\eta}^{2}, \widetilde{\eta}, \mu_j\right). \tag{11}$$

See Appendix B for the expression of the likelihood function under the assumption that both η_i and μ_j are normally distributed.

5 Data: the ICRISAT villages

The dataset used is part of the Village Level Studies data collected by the International Crops Research Institute for the Semi-Arid Tropics in India (ICRISAT).[18] From mid-1975 till mid-1985 the Institute surveyed a panel of farming households in the Indian semi-arid tropic regions in the states of Andhra Pradesh, Maharashtra, Gujarat and Madya Pradesh.

[17] See Appendix B for an explanation of how these results are derived and for the exact expressions obtained for the thresholds.

[18] See Walker and Ryan (1990) (W-R henceforth) for an extensive description of data collection and analysis.

Two villages were surveyed for each of the five districts selected to represent the different agro-climatic zones, but in only three districts data collection started from 1975 and covered all schedules (or surveys). For each of these three districts (Mahbubnagar, Sholapur and Akola) one village was followed throughout the ten years (the so called "continuous" village), while the companion village belonging to the same district was followed only until 1978 (the "closed" village). A total number of 240 households (40 for each village) were included in the initial survey sample and followed for the subsequent years. Households dropping out of the sample due to migration or death of the head of the household were replaced by a 'similar' household according to stratification within each village. Information collected is extremely varied, ranging from household's demographic characteristics, to wealth, labor and agricultural income, farming choices, etc.

Here analysis is restricted to the six villages in the districts of Mahbubnagar, Sholapur and Akola. All information on plot characteristics and production activity is retrieved from the Plot and Cultivation Summary Schedule. The ownership status of a plot is recorded as a categorical variable. In particular a plot can be 'owner-operated', 'leased-in' or 'sharecropped-in'. Plots who are owner-operated are not necessarily plots under a wage contract. Some of these plots may in fact be managed by the owner with the use of only family labor. To distinguish between family-operated plots and plots under wage contracts we use information contained in the Labor Utilization Schedule. Specifically we consider a plot to be operated under a wage contract if during the cropping season the owner hired *at least one attached male laborer on a full time basis.*[19]

a) Uncertainty measure

Most of the empirical literature analyzing the relation between contract choice and output risk uses crop yield coefficients of variation to proxy for farming uncertainty. This procedure has two major drawbacks. First, yield coefficients of variation include variability due to input choices, individual farming skills and idiosyncratic shocks. While the first two sources of variation are endogenous, only the last actually represents exogenous idiosyncratic farming risk.[20] Second, crop yield coefficients of variation measure the output risk of cultivating a specific crop. This is a

[19] Hired female labor is extensively used in farming, even at full time level. In a small number of cases female labor was the only source of hired full time labor. However we consider those plots as family-operated and not as plots under wage contracts. The reason is that in our model wage contracts constitute an alternative occupational choice to tenurial contracts. As in these villages landlords contract with men, women do not face the occupational choice set we are considering.

[20] Already in Allen and Lueck (1999) it is argued about the importance of separately identifying the endogenous and the exogenous sources of variation.

legitimate measure of idiosyncratic risk for a given plot only if the crop planted is exogenous, i.e. determined by circumstances such as soil characteristics and/or weather. In some agrarian economies, however, the landlord and/or the tenant may be able to decide the combination of crops to plant, so that any measure of risk related to the crop cultivated on a specific plot would be endogenous. Finally yield variability is only one source of crop income risk for farmers. Barah and Binswanger (1982) analyze the relative importance of crop price and yield variability for the ICRISAT villages, showing that indeed price variability was the dominant source of uncertainty in the irrigated areas.

We construct our measure of risk by estimating a production function conditioning on input choices and with a random individual effect. In this way we are able to a) purge the output variation due to input choices and other observable characteristics, and b) separate the variation due to idiosyncratic farming risk from the variation due to individual skills. By conditioning the estimates of the variance of the idiosyncratic error on plot characteristics such as soil type, presence of irrigation devices and district location, we obtain a measure of output risk that varies across plots, but is independent of the crops planted. The district location dummies capture the effect on output variability of the different weather conditions and rainfall variability across districts, while soil type and irrigation devices take into account the dependence of the specific plot on rainfall. We refer to this as a measure of *ex-ante* uncertainty of the plot, as opposed to the measure of *ex-post* uncertainty obtained by conditioning the variance of the random error on crop choice. Clearly if there is a high correlation between the crop planted and the characteristics of the plot, the two uncertainty measures should be highly correlated and it should not matter for our analysis which one to use. Finally as we consider nominal output, the estimated variance of the random error includes both yield and price variability. See Appendix C for details.

b) Contract payments

To estimate the models as defined in eq.(11) we need information about the payments associated with the three contracts, i.e. rent payments, output shares and wages. In particular not only do we need to know the payments associated with the contract actually signed on a specific plot, but also the 'shadow' payments that would have prevailed had a different contract been signed on that plot. Given that we can observe only the payments associated with the contracts actually chosen, we need to impute the implicit payments for the contracts not chosen.

Rent. There are 89 plots under fixed rent contracts over all years and villages in the sample.

We have information on the actual rents paid for only 78 plots.[21] We impute the rents for the 11 unmatched plots and the plots observed under alternative contracts using the predicted values from a log-linear model estimated on the observed rents. Given that the model is specified in terms of full rent paid and not base rent, a selection problem may arise if plots with certain unobservable characteristics are more likely to be observed under fixed rent contracts. To correct for potential selection bias, we use a two-stage Heckman correction model. See Appendix C for details.

Share. We fix the shares to be always 50-50. As pointed out in W-R, there is a certain variability in the leasing conditions across and within villages. In most villages the 50-50 rule is applied but sometimes the share for the tenant is increased during the cropping season if the landlord fails to provide his share of seed and fertilizer costs. In some cases the tenants have to provide most of the input and so their share can vary between 50 and 75 percent. Recently Banerjee et al. (2000) show that until 1977 more than 80 percent of share tenancy contracts in West Bengal implied a 50-50 rule, but after 1977 tenants' shares increased as a result of Operation Barga, a program launched by the left-wing administration and aimed at implementing the Land Reform Act. Unfortunately it was impossible to obtain reliable estimates of output shares and we choose the 50-50 rule, as it is by far the most common rule, and it is indeed the rule on which agents agree when signing the contract, though sometimes renegotiated at a later moment. Furthermore no program was ever launched in the study area to increase the tenants' share.

Wage. Our definition of attached laborer hired under an agrarian wage contract fits the description of *Regular Farm Servants* as defined in W-R. In the district of Mahbubnagar and Sholapur wages for this type of workers are a combination of cash and kind payments, while in Akola wages are only in cash. W-R documents that personal characteristics do not influence wages in any ICRISAT village and that kind and real cash wage are substantially the same across workers in the same village and have remained unchanged over the years. In our dataset wages for specific workers hired are not directly available, therefore we instrument wages with a set of village dummies.

A main limitation of our empirical analysis is the lack of personal information on agents matched. This impede us to control for eventual heterogeneity in risk aversion within the groups of tenants and landlords, so that we can only estimate average coefficients of risk aversion.

[21] The actual rents paid are recorded in the Transaction Schedule that collects information on all monetary and kind transactions involving the sampled households.

6 Results

6.1 Summary statistics

In the upper panel of Table 1 we report the frequencies of each contract type by district and village. The unit of observation is the plot.[22] There is a great variability across districts and across villages within district in the incidence of share tenancy and wage contracts. In the district of Mahbubnagar and Akola only about 10 and 21 percent of the plots are sharecropped respectively, while most plots (about 80 percent) are operated under wage contracts. In the district of Sholapur instead sharecropping is the most usual farming arrangement with 71 out of 100 plots sharecropped. In all districts only a small percentage of plots ranging from 0.4 to 7 percent is cultivated under fixed rent contracts. Note that in the district of Mahbubnagar farming risk should be relatively high because rainfall is uncertain and soil is mainly red (i.e. with low moisture retaining capacity), while in Sholapur risk is more limited as the soil has very high water retaining capacity. Hence, these figures seems to suggest that sharecropping is indeed more widespread when farming risk is lower contrary to the predictions of the principal-agent model.

In the second panel of Table 1 we report the average cultivated area, number of subplots, percentage of irrigated over cultivated area, and plot value by contract type.[23] Leased and sharecropped plots are smaller. Higgs (1973) uses plot size as a proxy for the landlord's monitoring cost, the rationale being that the bigger the plot, the easier for the laborer to 'hide' and shirk effort, and therefore according to our model less likely should the plot be managed under a wage contract. However our data do not support this logic.

Fixed rent and share tenancy plots are less irrigated and of lower value than wage contract plots, suggesting the plausibility of the multitasking hypothesis on land. Landlords may fear that under fixed rent and sharecropping contracts tenants might shirk effort on plot maintenance given that their contracts are for short term (usually one or two cropping seasons). Therefore they prefer to keep more valuable plots or plots with better irrigation devices under their control for self-cultivation.

Next we investigate whether share tenancy is inefficient in terms of input intensities. According

[22] A main plot can be divided by the farmer into various subplots in order to cultivate a different crop on each of them.

[23] The estimated per acre value of every plot was obtained during the survey from some knowledgeable person in the village and it was based on the plot potential sale value considering location, irrigation, topography, etc.

to the Marshallian theory, in fact, inputs whose costs are totally borne by the tenants under share tenancy should be underprovided as the tenants can accrue only a portion of their marginal product; inputs whose costs are shared between the tenants and the landlords should instead be provided efficiently. This clearly holds only under the assumption that inputs' intensities are not enforceable by the landlord. Hence by analyzing input intensities we can have an idea of the degree of moral hazard present in these villages. In Table 2 we present means and standard deviations of key input-output variables by ownership status. The unit of observation is the subplot. We include in the analysis family-operated subplots where full time hired laborers are only women and children. These plots constitutes more than fifty per cent of the observations. Average output per acre on subplots under fixed rent contracts is not statistically different from the mean output value obtained on plots which are family operated (t=1.3), while average output value under sharecropping is significantly lower (t=8.3).[24] These differences in output value cannot be explained by systematic differences in plot quality or in crops cultivated. In fact 91 percent of the plots under sharecropping have deep to shallow black soil, which is the most fertile, against 79 percent of family operated plots and 61 percent of fixed rent plots. Furthermore there is not much difference in the type of cultivated crops as in all cases cereals count for more than fifty per cent of the production. Instead there seems to be differences in the input intensities. Labor, fertilizers, pesticides, organic manure, bullock power and machinery are systematically undersupplied under share tenancy, while there is no significant difference in the average use of these inputs under fixed rent contracts and in family-operated plots.[25] The use of seed seems to be lower in both fixed rent and share tenancy contracts, but the value of the seeds used depends on the type of crop planted. When comparing average seed values across contracts conditioning on the crop, there is no systematic difference across all contracts which may be explained with the practise that seeds are provided jointly by the landlord and tenant under share tenancy.[26] These findings therefore do suggest that share tenancy is inefficient *a' la* Marshall.

[24] The reason why we do not directly compare fixed rent and share tenancy contracts with wage contracts is that tenants taking up land under share tenancy or fixed rent contracts may decide to operate them at a family level, while wage contracts seem to be used by landlords who cultivate the land more intensively.

[25] When comparing inputs' intensity between sharecropped and family operated plots, all tests of mean equality rejected the null hypothesis at 1 percent level. When comparing the means of plots given under fixed rent contracts and family operated ones, the null could not be rejected at 5 percent for any of the mentioned inputs.

[26] This is consistent with Shaban (1987) who finds that the 'tenancy effect' for seeds is lower than for labor and bullock.

6.2 Testing the principal-agent framework

In this section we investigate whether in the ICRISAT villages crop choice is endogenous, and test the canonical predictions of the principal-agent framework.

In Table 3 we report the frequencies of crops planted by soil type. Across the different soil types there is little variation in crops cultivated. In all cases cereals are the most frequent crops (nearly 50 percent). Pulses are also frequently cultivated on all soil types with the exception of deep-shallow red soil, where oilseeds count for almost 40 percent of the crops planted. These results seem to suggest that soil characteristics affect crop choice only marginally, while farmer's decision making may play an important role.

The first panel of Table 4 shows the average *ex-ante* and *ex-post* output variance by contract type and the correlation between the two measures.[27] First of all, if the crop planted was exogenously determined by plot characteristics, we would expect the two measures of risk to be highly correlated independently of the type of contract. Instead we find that the correlation is low for plots under wage and fixed rent contracts (0.42 and 0.37 respectively), while it is very high for share tenancy plots (0.71), which suggests that the two measures of output uncertainty are picking up different types of risk and that crop choice is not exogenous. Secondly, we find that fixed rent plots have significantly lower ex-ante variability than share tenancy plots (t=4.9), while plots under wage contracts are significantly riskier than the ones under share tenancy (t=18.2). This result, related to the exogenous uncertainty of the plots, suggests that the incidence of share tenancy with respect to fixed rent contracts is negatively related to risk, which contradicts the main theoretical predictions of the principal-agent framework related to moral hazard in effort. On the other side, when looking at the average ex-post measure of uncertainty by contract type, we find that share tenancy is associated with significantly lower crop-related output variance than fixed rent contracts. This seems instead to support the presence of moral hazard in risk-taking behavior by the tenant: tenants under fixed rent contracts choose combinations of crops that are riskier, while share tenants choose more conservative techniques.

To further explore the issue of endogeneity of crop choice and presence of moral hazard in risk, in the second panel of Table 4 we report the percentages of plots whose ex-ante and ex-post

[27] As a single plot of land is usually subplotted and a different crop cultivated on each subplot, the *ex-post* output variance for the plot is constructed as a weighted average of the ex-post variance measures for the crops planted, with weights given by the fractions of plot area dedicated to the specific crops.

variability is below and above the average by contract type. Though 43 percent of wage contracts are signed on relatively less risky plots ex-ante, only 22 percent of them have a relatively low measure of ex-post risk. Similar pattern applies to the plots under fixed rent contracts, while for the sharecropped plots the majority of plots have relatively low ex-ante and ex-post uncertainty. This suggests that in the ICRISAT villages crop risk is an important margin in farming decision making and that farmers cultivating under wage and fixed rent contracts are more willing to take up risk through crop choice than share tenants.

In order to test in a more formal way the predictions of the principal-agent model in the case when crop is exogenous we estimate a multinomial logit model where the dependent variable can assume all possible outcomes, i.e. wage contract, sharecropping and fixed rent contract. The results are shown in Table 5. In column (1) we control for soil and season dummies, cultivated area, plot value and presence of irrigation devices for possible multitasking cost, and the exogenous risk related to plot characteristics; share tenancy contract is the base. The coefficient on ex-ante risk is significant at 1 percent confidence level for all outcomes but, contrary to the theoretical predictions, we find that the probability of observing share tenancy relative to fixed rent contracts decreases with risk. Wage contracts are, instead, found to be more frequently observed than sharecropping when risk increases, consistently with the Stiglitz model. In column (2) we use the same specification but control for risk through the crop-related measure of uncertainty and again find that risk increases the probability of observing both wage and fixed rent contracts relative to share tenancy. Hence under the assumption that crop choice is exogenous, the data reject the principal-agent framework.

To test the principal-agent model under the hypothesis that crop choice is endogenous we estimate a logit specification that controls also for risk-taking behavior by the tenant. The dependent variable now has only two outcomes, fixed rent contract vs. share tenancy, as only under such contracts the crop is chosen by the tenant. The point here is that we would like to understand whether there is risk-taking behavior through crop choice, that would invalidate the empirical practise of using crop risk as a measure of uncertainty to test the validity of the principal-agent model with moral hazard in effort. If such a risk-taking behavior exists, then we would expect the crop-related measure of risk to be significant even after controlling for exogenous risk and furthermore to have an effect on contract type opposite in sign with respect to the exogenous risk measure. Nonetheless, as there may be a certain degree of exogeneity in crop choice, the two measures may be sufficiently correlated to create a problem of multicollinearity in the regression. To avoid this we use the residuals of a regression of the ex-post over the ex-ante variance estimated *on the sample including all possible contracts*. Such measure of crop risk is therefore purged of possible exogeneity of crop choice that may exist independently of the type of contract signed on the plot, and is instead a measure of risk purely 'chosen' by the tenant. We find that both the coefficients on exogenous uncertainty and crop choice risk are significantly positive (at 5% and 1% significance level respectively), which means that there is significant risk-taking behavior by the tenant and that, even after controlling for it, the data refute the principal-agent prediction on the relation between exogenous risk and contract choice.

Given that crop uncertainty controls for risk-taking behavior by the tenant, it also controls for incentives on matching as described by Ackerberg and Botticini (2001). They argue that if tenants are heterogeneous in risk aversion, then efficiency would drive less risk-averse tenants on riskier plots under fixed rent contracts; so that the results in column 1 could be justified by heterogeneity in tenants' characteristics. However, if heterogeneity in tenants' risk aversion is controlled for, we should still observe that share tenancy prevails over fixed rent contracts on riskier plots. In such framework the choice of riskier crops would be dictated by tenants' attitude towards risk and not by limited liability. Hence, the ex-post measure of uncertainty, purged of possible correlation with the uncertainty inherent the plot, should capture fairly well heterogeneity in risk aversion and control for such incentive on matching.

6.3 Structural estimates

Table 6 shows the structural estimates obtained by estimating the competitive occupational choice model using as a measure of risk the ex-ante output variance. In the second column we report the estimates of the parameters entering the production function, while in the fourth column we report the parameters related to the multitasking and monitoring costs along with the coefficients of risk aversion.

The Cobb-Douglas share of labor is 0.91 while the share of land is equal to 0.005. As shift factors we control for plot value, irrigation, district, soil, season and a time trend. The underlying assumption is that within districts agents face the same prices for inputs and output, so that variation in input choices is due only to plot characteristics. We control for monitoring cost using the size of the plot as suggested by Higgs (1973), and the exogenous riskiness of the plot. The idea is that the more uncertain the environment is, then the more severe the incentive problem may be, and therefore the higher the shirking-monitoring cost associated with wage and share tenancy contracts. When uncertain is low, instead, the landlord may be able to identify ex-post the tenants' effort and therefore link his reward to the final output, ensuring in this way the efficient level of effort without incurring any monitoring cost. Hence we should expect higher risk to be associated with higher monitoring cost. We find that plot size has a significant negative effect on the monitoring cost, contrary to what expected, while risk affects monitoring cost positively, as expected. Multitasking cost is controlled for by plot value, soil dummies and presence of irrigation devices. Soil dummies and irrigation devices capture the degree of maintenance necessary for the plot. If a well or a pump are present on a plot for irrigation, then maintenance is required to keep them in good operative conditions for future seasons. Under share tenancy and fixed rent contracts the tenant has no incentive in devoting efforts and resources for the maintenance of the irrigation devices. Hence, we would expect that the presence of an irrigation device increases the multitasking cost incurred by the landlord under such contracts and, consistently with this, we find that the coefficient on the irrigation dummy is positive and significant. The fact that the plot value still has a significantly positive effect on the multitasking cost after controlling for soil type and irrigation may be consistent with the fact that the market for land is very thin. Landowners who cannot sell their 'low' quality plots and cannot cultivate them, are more likely to rent them out either under share tenancy or under fixed rent contracts.

The estimated coefficient of absolute risk aversion is equal to 2.25 for tenants and 1.27 for landlords; they are both significantly positive and the test on their equality is rejected at 1% level ($\chi^2_{(1)} = 6.84$), meaning that tenants are significantly more risk averse than landlords. The coefficient on the variance of individual skills is 0.05 and is not significantly different from zero. Such coefficient should be equal to the constant absolute risk aversion coefficient for landlords if tenants' skills were indeed private information and constituted a source of income uncertainty for the landlord under share tenancy. From this we can conclude that information on farming ability is spread within the ICRISAT villages. Finally δ is estimated to be equal to 0.57, meaning that under share tenancy landlords devote in monitoring about half the time spent under wage contracts.

These results shows that both landlords and tenants are sensitive to the cultivation risk, and, as they are risk averse, their choice of the optimal contract is affected by risk-sharing considerations. Moral hazard in the form of shirking and multitasking cost also plays an important role in the landlords' decision of which contract to offer.

In order to see if our model can predict the observed 'reduced form' relation between contract distribution and risk, Table 7 shows the actual and predicted probabilities of each contract by district and village.[28] The predicted probabilities are fairly close to the actual ones. In the lower panel we report the actual and predicted frequencies of each contract when ex-post output variability is below and above the average. Even here the predictions capture the pattern found in the data closely. More specifically the predicted probability of observing share tenancy relative to fixed rent contracts increases with risk while the probability of observing share tenancy relative to wage contracts decreases with risk. Therefore our model can replicate the relation between the equilibrium distribution of contracts and risk. This is in sharp contrast to the inability of the principal-agent model to explain the observed pattern.

7 Conclusions

The existing theoretical literature analyzes the determinants of contract choice in agrarian economies using 'partial equilibrium' principal-agent models, where the shape of the contract is unilaterally determined by only one of the contracting parties. Their predictions regarding the relation between farming risk and incidence of share tenancy have been tested in a number of studies and found sometimes to be at odds with empirical evidence.

The aim of this paper is twofold. First, we tested the predictions of agency theory models taking into account possible endogeneity of crop choice, which was not considered in previous studies and, therefore, may have hindered their results. Using Indian data, we find that principal-agent models with moral hazard in effort are rejected by our data. Second, we construct a structural econometric model based on an alternative theoretical framework where both landlords and tenants choose the contract they prefer considering as given the contractual terms, as in a competitive framework. The structural estimates allow to separate the risk-sharing motive from the incentive one, and to evaluate the effect of risk on the two sides of the market. In this way we can reassess the role of risk-sharing in contract choice by looking at the effect of risk on the individual choices, while the observed relation between risk and distribution of contract is seen as the aggregate result in

[28] Such predicted probabilities can be obtained by looking at the choice distribution of either the landlords or the tenants. We report the ones obtained from the tenants' preferences. The predicted probabilities computed from the landlords' preferences have similar patterns.

equilibrium of the interaction between the different agents. We find that both landlords and tenants are risk averse, hence the risk sharing motive through contract choice exists after controlling for moral hazard, and that the type of framework proposed is able to reproduce the empirical relation between contracts' incidence and uncertainty as a 'reduced form' relation.

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Table 1: Means of key variables by main plots
(standard deviations in parenthesis)

	Wage contract	Fixed-rent	Share-crop
Plots (%)	57.0	3.7	39.3
DISTRICT (Village)			
Mahbubnagar	**82.0**	**7.9**	**10.1**
Aurepalle	89.0	8.9	2.1
Dokur	56.1	3.8	40.1
Sholapur	**28.4**	**0.4**	**71.2**
Shirapur	20.4	0.4	79.2
Kalman	37.4	0.4	62.6
Akola	**74.5**	**4.7**	**20.8**
Kanzara	75.9	5.7	18.4
Kincheda	69.0	0.7	30.3
Cultivated area (acrs)	4.04 (3.56)	2.74 (1.77)	3.38 (3.21)
No. subplots	1.61 (0.98)	1.13 (0.42)	1.36 (0.80)
Irr/cult area (%)[1]	0.30 (0.44)	0.10 (0.30)	0.10 (0.29)
Per acre plot value[2]	25.44 (15.75)	16.84 (14.12)	20.43 (13.40)
Total	1373	89	947

[1] Percentage of irrigated area over cultivated area
[2] Plot value is in 100 Rupies.

Table 2: Means of key variables by subplots[3]
(standard deviations in parenthesis)

	All	Owner-operated		Fixed-rent	Share-crop
		Family operated	Wage contract		
Plot (%)		57.9	26.0	1.2	14.9
Cultivated area (acrs)	2.10	1.79	2.50	2.46	2.57
	(2.25)	(1.94)	(2.56)	(1.65)	(2.63)
Output per acre (vl)	0.58	0.55	0.79	0.42	0.31
	(0.95)	(1.02)	(0.97)	(0.43)	(0.51)
Labor per acre (hrs)	285.84	276.75	383.78	213.61	155.88
	(433.3)	(434.9)	(479.4)	(221.4)	(292.8)
Seed per acre (vl)	0.047	0.048	0.056	0.021	0.028
	(0.23)	(0.29)	(0.12)	(0.020)	(0.11)
Fertilizer per acre (vl)	0.034	0.027	0.062	0.034	0.012
	(0.089)	(0.083)	(0.109)	(0.063)	(0.052)
Organic manure per acre (vl)	0.015	0.015	0.023	0.006	0.002
	(0.064)	(0.064)	(0.078)	(0.024)	(0.021)
Pesticides per acre (vl)	0.003	0.002	0.007	0.002	0.0008
	(0.025)	(0.023)	(0.036)	(0.014)	(0.010)
Bullock power per acre (hrs)	43.10	40.47	58.49	42.56	26.47
	(58.03)	(56.96)	(68.45)	(36.58)	(31.47)
Bullock power (dummy)	0.98	0.98	0.99	1.00	0.98
Machinery per acre (vl)	0.049	0.052	0.053	0.008	0.034
	(0.19)	(0.22)	(0.16)	(0.03)	(0.16)
Machinery (dummy)	0.29	0.26	0.41	0.29	0.20
Irrigated (dummy)	0.26	0.24	0.37	0.10	0.12
Soil (dummy):					
deep-medium black	0.53	0.51	0.57	0.53	0.53
medium-shallow black	0.27	0.28	0.21	0.08	0.38
deep-shallow red	0.14	0.14	0.19	0.38	0.03
gravelly, saline, sandy	0.06	0.07	0.03	0.01	0.06
Crop (dummy):					
oilseeds	0.13	0.13	0.16	0.16	0.06
cereals	0.54	0.53	0.53	0.58	0.58
fiber-crops	0.11	0.10	0.15	0.16	0.07
pulses	0.16	0.16	0.09	0.09	0.26
vegetables	0.05	0.06	0.06	0.01	0.03
sugarcane	0.01	0.02	0.01	0.00	0.00
>1 crop	0.36	0.37	0.34	0.59	0.34
Total	8537	4946	2220	99	1272

[3] Values are in 1000 Rupies.

Table 3: Crop choice and soil type

Crops	Soil type			
	Deep-medium black	Medium-shallow black	Deep-shallow red	Gravelly, saline and sandy
Oilseeds	6.7	10.7	39.1	12.8
Cereals	53.0	57.6	53.3	49.2
Fiber-crops	15.6	8.8	1.1	0.2
Pulses	14.7	20.3	4.1	31.8
Vegetables	8.0	2.0	2.4	5.6
Sugarcane	2.0	0.6	0.0	0.4
Total	100	100	100	100

Table 4: Tenancy contracts and output variance

	Wage contract	Fixed-rent	Share-crop
Mean variability by contract type			
Ex-ante variance:	0.44	0.33	0.22
	(0.32)	(0.17)	(0.18)
Ex-post variance:	0.41	0.42	0.21
	(0.16)	(0.10)	(0.14)
Correlation:	0.42	0.37	0.71
Frequency of contracts by variability			
Ex-ante variance:			
Below mean variance	43.12	55.06	78.35
Above mean variance	56.88	44.94	21.65
Ex-post variance:			
Below mean variance	22.51	11.24	77.30
Above mean variance	77.49	88.76	22.70
N. obs.	1373	89	947

Table 5: Contract choice logistic models

Dependent variable: Contract type (p-values in parenthesis, * significant at 1%, ** significant at 5%)			
	(1)	(2)	(3)
Wage contract			
Total area	0.493*	0.012*	
	(0.00)	(0.01)	
Plot value	0.013*	0.008**	
	(0.00)	(0.04)	
Irrigation device (dummy)	0.455*	1.016*	
	(0.01)	(0.00)	
Ex-ante risk	3.199*		
	(0.00)		
Ex-post risk		5.825*	
		(0.00)	
Constant	-18.623*	-19.621*	
	(0.00)	(0.00)	
Fixed rent contract			
Total area	-0.212*	-0.260*	-0.208*
	(0.00)	(0.00)	(0.00)
Plot value	-0.036*	-0.040*	-0.028**
	(0.00)	(0.00)	(0.03)
Irrigation device (dummy)	-0.771	-0.103	0.707
	(0.14)	(0.80)	(0.26)
Ex-ante risk	3.341*		2.680**
	(0.00)		(0.02)
Ex-post risk		6.026*	
		(0.00)	
Constant	-17.953*	-18.986*	-16.435*
	(0.00)	(0.00)	(0.00)
Ex-post risk (residuals)			8.251*
			(0.00)
Pseudo-R^2	0.1982	0.2538	0.3764
Log-likelihood	-1563.30	-1454.89	-189.27
No. Obs.	2409	1036	1036

In all specifications season and soil dummies are included.
Model (1): multinomial logit model, share tenancy is the base, with ex-ante variance.
Model (2): multinomial logit model, share tenancy is the base, with ex-ante variance.
Model (3): logit model for dichotomous variable equal to 1 if fixed rent contract is observed, equal to 0 if share tenancy is observed.
Ex-post risk variable is constructed as the residuals of a regression of ex-post output variance over ex-ante variance.

Table 6: Structural estimates

Dependent variable: contract type
Log-likelihood:-3546.83; N. obs. 2409
(p-values in parenthesis; * significant at 1%, ** significant at 5%)

Variables	Coefficients	Variables	Coefficients
Production function[4]:		Monitoring cost:	
Cultivated area (share)	0.005* (0.00)	Cultivated area	-0.063* (0.00)
Labor hours (share)	0.917* (0.00)	Ex-ante risk	2.473* (0.00)
β_1 :		Constant	-1.509* (0.00)
Irrigation (dummy)	0.073* (0.00)	Multitasking cost:	
Time trend	0.092* (0.00)	Plot value	0.007* (0.00)
Constant	-6.314* (0.00)	Irrigation (dummy)	0.538* (0.00)
$\beta_1^{'}$:		Deep-medium black soil	-0.176 (0.06)
Irrigation (dummy)	0.293* (0.00)	Medium-shallow black soil	-0.224* (0.01)
Time trend	0.086* (0.00)	Deep-shallow red soil	-0.610* (0.00)
Constant	-6.392* (0.00)	Gravelly, saline, sandy	0.139 (0.13)
		Preferences:	
		Tenant CARA	2.249* (0.00)
		Landlord CARA	1.269* (0.00)
		Skill variance	0.039 (0.67)
		Delta	0.575* (0.00)

[4] Village, soil and season dummies are included.

Table 7: Actual and predicted probabilities:
(predicted probabilities in brackets)

	Wage contract	Fixed-rent	Share-crop
DISTRICT (Village)			
Mahbubnagar	**82.0** **(83.2)**	**7.9** **(7.4)**	**10.1** **(9.4)**
Aurepalle	89.0 (90.2)	8.9 (9.5)	2.1 (0.3)
Dokur	56.1 (57.2)	3.8 (0.2)	40.1 (42.6)
Sholapur	**28.4** **(29.7)**	**0.4** **(0.3)**	**71.2** **(70.0)**
Shirapur	20.4 (18.9)	0.4 (0.0)	79.2 (81.1)
Kalman	37.4 (36.3)	0.4 (0.7)	62.6 (63.0)
Akola	**74.5** **(78.7)**	**4.7** **(1.5)**	**20.8** **(19.8)**
Kanzara	75.9 (80.4)	5.7 (1.5)	18.4 (18.0)
Kincheda	69.0 (71.7)	0.7 (1.2)	30.3 (27.1)
Ex-ante variance:			
Below	42.8 (45.1)	3.5 (3.2)	53.7 (51.5)
Above	76.1 (73.6)	3.9 (2.7)	20.0 (23.7)
Total	1373	89	947

Table A1: Estimates of Cobb-Douglas production function

Dependent variable: output value (1000 Rupies)
(* significant at 1%, ** significant at 5%)

Variables	(1)		(2)	
	Coefficient	P-values	Coefficient	P-values
Cultivated area (share)	0.216*	0.00	0.235*	0.00
Labor hours (share)	0.810*	0.00	0.815*	0.00
Seed value	0.236*	0.00	0.243*	0.00
Bullock power (hrs)	-0.00067*	0.00	-0.00077*	0.00
Machinery value	-0.045*	0.00	-0.056*	0.00
Fertilizer value	0.306*	0.00	0.299*	0.00
Organic manure value	0.174*	0.00	0.177*	0.00
Pesticide value	0.392*	0.00	0.452*	0.00
Irrigation (dummy)	-0.011	0.55	0.013	0.47
Plot value	0.005**	0.04	0.005**	0.04
>1 crop	-0.062*	0.00	-0.083*	0.00
Time trend	0.076*	0.00	0.072*	0.00
Constant	-5.460*	0.00	-5.539*	0.00
N. obs.	8537		8537	
Log-likelihood	-6563.36		-6764.32	

In both specification: season, soil, crop and district dummies are included; time-effect is proxied by year and season dummies; individual effect variance is conditional on village and contract type.
Model (1): random-effect variance is conditional on soil, district and irrigation dummies.
Model (2): random-effect variance is conditional on crop and district dummies.

Table A2: Estimates of selection model for rent payments
(two-step estimation)

Dependent variable[5]:
(a) natural log of rent (structural eq.)
(b) fixed rent contract vs. others (selection eq.)
(p-values in parenthesis, * significant at 1%, ** significant at 5%)

Variables	(1)		(2)	
	(a) Structural	(b) Selection	(a) Structural	(b) Selection
Cultivated area	0.392	-0.131*	0.215	-0.130*
	(0.08)	(0.00)	(0.08)	(0.00)
Ex-ante variance	24.702	-15.036**		-0.125
	(0.45)	(0.04)		(0.86)
Ex-ante variance^2	-6.123	6.053**		
	(0.63)	(0.04)		
Soil dummies:				
Deep-medium black	-2.632	0.780	-1.810	0.414
	(0.20)	(0.14)	(0.032)	(0.42)
Medium-shallow black	-2.304	-0.768	-4.309**	-0.061
	(0.42)	(0.24)	(0.03)	(0.90)
Deep-shallow red	-6.910**	1.754*	-4.403*	0.690
	(0.03)	(0.01)	(0.01)	(0.17)
Irrigation (dummy)	-8.813	3.009	-3.232*	-0.607
	(0.24)	(0.10)	(0.00)	(0.13)
District dummies:				
Mahbubnagar	6.092	-3.271		0.127
	(0.43)	(0.06)		(0.72)
Sholapur	9.422	-4.510*		-1.215*
	(0.32)	(0.01)		(0.00)
Plot value		-0.019*		-0.018*
		(0.00)		(0.00)
Individual-effect variance		0.182		
		(0.99)		
Season dummies:				
Kharif		0.151		0.215
		(0.74)		(0.64)
Rabi		0.012		0.023
		(0.97)		(0.96)
Constant	-8.515	4.015	-2.514	-1.233
	(0.44)	(0.14)	(0.22)	(0.11)
Mills lambda	-0.953		1.109	
	(0.60)		(0.08)	
N. obs.	78	2309	78	2309

[5] Values are in 1000 Rupies.