Evidence on the Incentive Properties of Share Contracts

Luis H. B. Braido[*][†]

August 2, 2005

Abstract

Ever since Adam Smith, share contracts have been condemned for their lack of incentives. Sharecropping tenants face incentives to undersupply productive inputs since they receive only a fraction of the marginal revenue. The empirical literature reports that lands under sharecropping are less productive and employ inputs less intensively than those operated by owners. This paper shows that: (i) share contracts are also associated with lower-quality lands; (ii) the sharecroppers' input choices satisfy profit-maximization conditions; and (iii) the contract form does not affect farm productivity conditional on land quality and input use. These findings suggest that farmers optimally choose to employ inputs less intensively in lower-quality lands under sharecropping and, then, these lands end up being less productive. Land-quality selection bias (as opposite to incentives) seems to be behind the existing evidence on the productive disadvantage of share contracts.

Keywords: Econometric test, moral hazard, development, tenancy data, selection bias. JEL Classification: C52, D82, O12, Q15.

[*]This paper is based on an essay from my Ph.D. dissertation at the University of Chicago. I am thankful for comments from Juliano Assunção, Pedro Carneiro, Rodrigo Cerda, Pierre-André Chiappori, Bev Dahlby, Mark Duggan, Maitreesh Ghatak, Milton Harris, D. Gale Johnson, Steven Levitt, Derek Neal, Lars Stole, two anonymous referees, and participants in the following meetings: CESifo (Venice, 2003), Econometric Society (Washington D.C., 2003), SBE (Nova Friburgo, 2002), LACEA (Madrid, 2002), and LAMES (São Paulo, 2002). Financial support from CNPq is gratefully acknowledged.

[†]Graduate School of Economics, Getulio Vargas Foundation; Praia de Botafogo 190, s.1100, Rio de Janeiro, RJ 22253-900, Brazil; lbraido@fgv.br.

1 Introduction

Throughout time, lands have been cultivated under three basic contract forms: (i) ownership, where the farm is managed by its owner; (ii) fixed-rent tenancy, where the tenant pays an upfront rent for the landowner, bears the costs with nonlabor and labor inputs, and retains the final output; and (iii) sharecropping tenancy, where the landlord supplies the land, the tenant bears the input costs, and they share the final output.[1] Classical authors such as Adam Smith, Anne R.J. Turgot, John S. Mill, and Alfred Marshall condemned the sharecropping tenancy for its lack of incentives. Since sharecropping tenants bear the marginal costs and receive only a fraction of the marginal revenue, they face incentives to undersupply productive inputs such as seeds, pesticides, labor, and other hidden actions (e.g., managerial effort).[2]

The modern theory of moral hazard presents a rationale for the use of share contracts (as opposite to fixed rent) despite its incentive disadvantage.[3] In this literature, sharecropping is viewed as a constrained-efficient contract that balances incentives and risk sharing. By sharing the production risk, the landlord insure the tenant at the cost of reducing incentives for performance. Similarly to the classical authors, the static moral hazard theory predicts that the final output should be higher if the land contract were ownership or fixed rent instead of sharecropping (holding fixed all characteristics of the farmer and land).

On the other hand, there are theories predicting that similar farms cultivated under ownership, fixed rent, and sharecropping should be equally productive. Johnson (1950) argues that dynamic incentives compensate the low incentive power of share contracts. Sharecropping leases have usually short duration and the landlords renew these leases based on relative performance (i.e., by comparing the sharecropper's performance with those of adjoining owned and rented farms). Therefore, moving costs and risk of unemployment should act in the extensive margin and induce sharecroppers to behave properly. In a different vein, Cheung (1969) argues that landlords are able to perfectly monitor tenants' activities, especially in small villages where they have close relations. Moreover, recent models show that the

[1] In many cases, the sharecropping landlord also shares the cost of some inputs.

[2] These authors have also condemned tenancy contracts (both sharecropping and fixed rent) for inducing the tenants (who face tenure instability) to make suboptimal levels of land-specific investments that take time to mature. Among them, Adam Smith was the most critical—Mill and Marshall, for instance, acknowledge different mechanisms available to landlords to mitigate incentive problems. Potential holdup problems associated to long-term land-specific investments are not discussed in this paper. For references on this topic, see Johnson (1950); Banerjee, Gertler, and Ghatak (2002); Dubois (2002); Jacoby, Li, and Rozelle (2002); Jacoby and Mansuri (2002); and Bandiera (2002).

[3] See Stiglitz (1974); Holmström (1979); and Grossman and Hart (1983).

infinite repetition of the principal-agent relationship would approximately lead to first-best outcomes (see Rubinstein and Yaari, 1983; and Radner, 1985).[4]

The empirical side of this debate supports the classical prediction that the low incentive power of share contracts reduce farm productivity. In an influential work, Shaban (1987) shows that farmers who simultaneously own and sharecrop multiple plots are more productive and employ inputs more intensively in the fields they own. Other papers in the literature present similar results. However, this literature has ignored an important selection issue that might be driving these results. Since contracts are endogenous, they might be correlated to unobserved characteristics of the land. This paper presents robust evidence suggesting that the productivity disadvantage of sharecropping is strongly related to unobserved differences in land quality.

The paper accesses the same data source used by Shaban (1987), the Indian Village Level Studies, conducted by the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). The entire ICRISAT sample is studied throughout the paper for the sake of efficiency. The particular subsample used by Shaban, composed exclusively of farmers who simultaneously own and sharecrop multiple fields, is also analyzed in a final section (with no change in the results). The analysis starts by replicating the stylized fact that sharecropped lands are less productive and employ inputs less intensively than owner-operated fields. In a descriptive exercise (without controlling for plot's and farmer's characteristics), I found that owner-operated fields are about 40% more productive than those under sharecropping and fixed rent. These plots are also 17% more valuable and use 43% and 41% more of nonlabor and labor inputs (respectively). Productivity, land value, and input use are not statistically different across plots under fixed rent and sharecropping.

I then model the log output (in monetary units per acre) as a function of dummy variables for each land contract and other control variables—namely, (i) controls for land and cropping characteristics (such as land value, irrigation, soil type, main crop, year, and season); and (ii) fixed effects for households in each period which, like in Shaban (1987), control for unobserved characteristics of the farmers. Similarly to Shaban, this conditional productivity is about 23% higher in owned farms (relatively to lands under sharecropping). Additionally, I also find that this conditional productivity is statistically equal across lands under fixed rent and sharecropping. This latter finding does not support the existence of incentive problems associated with the low incentive power of share contracts since, like owners, fixed-rent tenants retain 100% of the final output. However, this evidence is weak since the fraction

[4] First-best results could also be approximated in finite-horizon scenarios if one worked with the epsilon equilibrium concept defined by Radner (1981).

of plots under fixed rent is very small (less than 2% of the sample).

There are theory and evidence suggesting that good lands are less likely to be leased out because they are more sensitive to soil exploitation (see Allen and Lueck, 1992 and 1993; and Dubois, 2002). Underinvestment resulting from holdup problems could be another explanation for the lower quality of leased lands (see Dubois, 2002; Jacoby, Li, and Rozelle, 2002; Jacoby and Mansuri, 2002; and Bandiera, 2002). If owner-operated lands displayed better unobserved characteristics, it could be efficient for these farms to employ inputs more intensively and, consequently, be more productive (land-quality selection bias). Confirming this suspicion, the productivity advantage of owned lands vanishes when I introduce either nonlabor or labor input as control variable into the log-output regression. Lands under sharecropping and fixed rent are less productive essentially because they have lower quality and use inputs less intensively.

This result suggests that the productivity disadvantage of sharecropping is not due to hidden actions (i.e., actions that cannot be inferred from the input choices or other observable variables). However, it could be due to underutilization of nonlabor and labor inputs. I then develop a structural procedure to test for the existence of incentive distortions affecting tenants' input choices. Profit-maximization conditions imply that the marginal productivity of each factor should be constant across farms under different land contracts. This prediction is robust to unobserved heterogeneity in land quality and farmer ability. When the technology is Cobb-Douglas, the marginal productivity is easily measured by the average productivity. This production function is used in the test, and the data do not reject the hypothesis that marginal productivity is constant across farms under ownership, fixed rent, and sharecropping. The input choices do not appear to be distorted by the contract form, casting doubts on the importance of problems associated with the reduced incentives under share contracts.

Given this, I re-estimate the production function imposing the profit-maximization conditions as restrictions, in order to account for input endogeneity (see Greene, 2003). In this exercise, farm productivity remains constant across land contracts, confirming the suspicious that better lands in the hands of owners create a positive correlation between ownership and land productivity.

The main point here can be summarized as follows. For some reason, the better lands end up being managed by their owners. Facing lower-quality lands, sharecropping tenants optimally choose to use inputs less intensively than owners and, then, regressions comparing productivity across lands under different contracts inconsistently associate lower farm productivity with the sharecropping contract. The idea that share contracts reduce productivity is widespread in economics and pervades the debate on land reform in the developing world. The findings in this paper suggest that the existing evidence on the sharecropping productivity disadvantage may be a simple statistical artifact resulting from unobserved heterogeneity in land quality.

The remainder of the paper is organized as follows. The related literature is revised in Section 2, and the data set is described in Section 3. In Section 4, I introduce the econometric model and present the results on land productivity. Section 5 tests for the existence of distorted incentives for input use, and Section 6 estimates the production function imposing the profit-maximization conditions. In Section 7, the subsample of mixed owner-sharecropper (as defined in Shaban, 1987) is used to check the robustness of the previous results. Concluding remarks appear in Section 8.

2 Related Literature

There are three main references in the empirical literature.[5] In a pioneering work, Rao (1971) studies many different issues related to the design of land contracts and their impact on productivity. For the analysis on incentives and land productivity (pp. 588), Rao uses farm level data from the Studies in Economics of Farm Management collected by the Government of India, during the 1957-58 and 1958-59 cropping years, in two different production zones (namely, rice and tobacco zones). Arguing that there is a high correlation between land quality and the amount of different inputs used, this work estimates a Cobb-Douglas production function where land quality (measured by imputed values of land resources) is the only independent variable. The results are ambiguous. The OLS estimation shows that the per acre output is higher in owner-operated fields than in sharecropped farms, but observed land quality explains around 90% of the output variation. However, when Rao estimates different production functions for different farm sizes, the result is inverted. The output per unit of land is higher in sharecropped lands than in owner-operated farms of corresponding size.

In another classical work, Shaban (1987) uses a subsample of the ICRISAT Village Level Studies composed of sharecropping tenants who also own some land (mixed owner-sharecropper). He shows that these farmers are more productive and use inputs more intensively in the lands they own than in the fields they rent under sharecropping. This is interpreted as evidence of incentive problems. The estimates are constructed by comparing owned and sharecropped farms for each household in a given period. Therefore, the results are free of potential selection bias caused by

[5] For additional references on the empirical tenancy literature, see Braido (2005).

unobserved heterogeneity in farmer's characteristics. Land-quality heterogeneity is taken into account through linear regressors such as the land value, irrigated area, and dummies for the soil type.

The third main reference is Laffont and Matoussi (1995), who use Tunisian data and show that sharecroppers are less productive than owners and fixed-rent tenants. They define a log-linear specification for the production function in which the plot's area, the cost of nonlabor inputs, and the amount of family and hired labor (measured in days) are used as regressors. Household characteristics and the type of crop are used in the regressions, but no control for the quality of land is available.

Therefore, the existing empirical literature strongly suggests that the low incentive power of share contracts reduces land productivity. The findings in this paper challenge this idea and support an alternative view that the lower productivity of sharecropping is related to land-quality selection bias.

3 Data Description

The data set used here is part of the longitudinal village level studies (VLS) conducted by the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in India. The study was conducted from 1975 to 1984 in villages intended to represent major agroclimatic zones of India. Initially, six villages were selected in two different states: Aurapalle and Dokur (in the state of Andhra); and Kanzara, Kinkheda, Shirapur, and Kalman (in the state of Maharashtra). Later, in 1980, the villages of Boriya and Rampura (in the state of Gujarat) were also included in the study.

For each village, 10 households were randomly selected in each of the following four categories: landless workers, and large, medium, and small farmers (a total of 40 households per village). Random replacement within each category occurred whenever a household emigrated from the village. Resident investigators belonging to the same linguistic group as the villagers collected information on farming activities in all plots managed by these households. The investigators had rural backgrounds and their work was supervised by economists from the ICRISAT. The interviews were conducted regularly throughout each cropping year, and the investigators attended local meetings in order to be close to the villagers. The villagers were informed about the purpose of the survey and understood the ICRISAT is an independent research center. These details are important because Ray (1998, footnote 2, pp. 421) suggests that leasing from large to small farmers might be underreported in the ICRISAT data since landowners fear the land-to-the-tiller legislation (which confers property rights on tenants after they have cultivated the land for a certain number of years). This is a general concern about official tenancy data in India. However, Shaban (1987, pp. 898) claims that the ICRISAT data do not suffer from this problem since "it would be difficult to hide information from an investigator who lives in the village all year round and who usually gains the confidence of the villagers." Further details about the data collection can be found in Jodha, Asokan, and Ryan (1977); Singh, Binswanger, and Jodha (1985); and Walker and Ryan (1990).

The schedule used (the PS files) contains plot-level information on farming activities and plot characteristics, for all plots of each household in each year and season. The household is the primary sampling unit of this research, but the PS files display disaggregated information on each plot of the households. The panel is not balanced since farmers crop different plots over time. The following variables are used in the analysis: the per acre value of the output; dummies for the land contract (ownership, fixed rent, and sharecropping); the per acre value of nonlabor and labor inputs; estimated per acre value of the plot; a dummy variable indicating presence of irrigation; and dummies for the soil type, main crop, village, year, and season. Table 1 describes these variables in details.

[Table 1]

It is important to stress how values were computed by the ICRISAT investigators. The actual value paid for seeds, fertilizers, pesticides, and manures and the rental value of rented bullocks and machinery (such as pumpsets and tractors) were recorded. For home produced inputs and owned bullocks and machinery, the values were computed by multiplying the actual quantities by village-specific prices and rents. Similarly, the data display the actual value paid for hired labor, while the value of family labor is computed by multiplying the village wages for children, male adults, and female adults by the number of hours worked by each member. Finally, the value of the main product and byproducts were recorded at the prevailing village prices at the time of harvest.

According to Jodha (1981), tenants are very heterogeneous in these Indian villages, and many small farmers rent their plots to larger farmers (with better resources) in exchange for advance payments. Sharecropping landlords are usually close to tenants, and the majority of these plots are leased for short periods (from one season to one year). On the other hand, most long-term leases involve fixed-rent payments to absentee landlords. There is also variation in the share of output retained by sharecroppers, which is typically between 50% and 75% of the total output.[6] In normal circumstances, landlords also share the costs of most inputs.

[6] In some cases, only the value of the main product is shared and the tenant retains the byprod-

The fraction of each input borne by the landlord usually depends on the crop and whether the land has soil problems. In some cases, tenants have wide discretion about the crops to be planted. However, landlords tend to determine the crop when dealing with poor sharecroppers.

There are plots that produce no output in some seasons.[7] These are likely to be plots under rotation or temporarily abandoned after extreme shocks (such as infestations). These plots are ignored in the analysis here—mainly because of the log-linear specification used throughout the paper.[8] Table 2 presents the summary statistics for the 10,704 productive plots.

[Table 2]

The data is collected in different villages, years, and seasons and all monetary values are nominal. Therefore, it is important to control for these features when comparing sample means. Table 3 displays four linear regressions of the log of the output, land value, labor and nonlabor inputs (measured in monetary units per acre) against dummy variables for the land contract, village, year, and season. Column (a) shows that owner-operated plots are on average 42% more productive than lands under sharecropping and fixed rent. These fields are also 17% more valuable and use nonlabor and labor inputs more intensively (about 43% and 41%, respectively), as shown in columns (b)-(d). The productivity advantage of owned plots (42%) seems to be related to input use (43% and 41%). Note also from Table 3 that lands under fixed rent are less productive (-3%) and less valuable (-7%) than lands under sharecropping, but these differences are not statistically significant.

[Table 3]

A key characteristic of the data is the presence of farmers cropping multiple plots under different contracts in each period (season of the year). On average, each farmer cultivates 3.86 plots per period, and 93.6% of the plots were managed by farmers

---

ucts. This is not particularly relevant for my analysis since byproducts account for a very small fraction of the total output and the correlation between the value of main and secondary products is very high.

[7] There are 813 plots producing no output out of 11,517 plots sampled.

[8] It would be interesting to test whether the tenancy contract affected the likelihood of a plot been abandoned. However, two issues would arise in this exercise. First, the data do not allow one to separate plots under rotation from those abandoned. The decision of rotating a plot is related to long-term incentives to preserve land quality, an issue not studied in this paper. Moreover, the information on these unproductive plots is not rich enough to overcome the usual selection concerns—for instance, the tenancy contract might be endogenously related to the risk of extreme shocks and the decision of abandoning a plot might depend on farmers unobserved characteristics.

who cropped two or more plots in that particular period. Among the 10,704 plots sampled, one has: 6,876 plots managed by farmers who only had lands under ownership in that particular period (pure owner); 252 plots managed by farmers who only had lands under sharecropping in that particular period (pure sharecropper); 37 plots managed by farmers who only had lands under fixed rent in that particular period (pure renter); 2,833 plots managed by farmers who own and sharecrop different plots in that particular period (mixed owner-sharecropper); 456 plots managed by farmers with plots under ownership and fixed rent in that particular period (mixed owner-renter); 5 plots managed by managed by farmers with plots under sharecropping and fixed rent in that particular period (mixed sharecropper-renter); and 245 plots managed by farmers with lands under ownership, sharecropping, and fixed rent in that particular period (mixed owner-renter-sharecropper).

4 Land Productivity

As is usual in agricultural economics, I use a Cobb-Douglas production function with constant return to scale to model the production of each plot. This functional form is flexible and allows one to mimic and extend Shaban's (1987) findings on land productivity. Define Y_i as the amount of output produced in plot i, where i indexes the plots in each particular period (year and season), and assume that:

$$Y_i = A_i K_i^{\alpha_k} L_i^{\alpha_l} T_i^{(1-\alpha_k-\alpha_l)} \exp\left(\varepsilon_i\right), \tag{1}$$

where K_i and L_i represent the amount of nonlabor and labor input used; T_i is the cropped area; A_i is a technological factor that accounts for observable household and land characteristics as well as specific effects associated to each village, year, season, and crop grown; α_k, and α_l are positive parameters; and ε_i is an unobserved error term accounting for possible hidden actions, unobserved characteristics of farms and farmers, climatic shocks, and infestations.

Multiplying quantities by their respective prices (p_y, p_k, and p_l) and dividing both sides by T_i, one obtains the production function expressed in monetary units per acre as follows:

$$y_i = a_i k_i^{\alpha_k} l_i^{\alpha_l} \exp\left(\varepsilon_i\right), \tag{2}$$

where $y_i = \frac{p_y Y_i}{T_i}$ represents the per acre value of plot i's output; $k_i = \frac{p_k K_i}{T_i}$ and $l_i = \frac{p_l L_i}{T_i}$ are the per acre value of nonlabor and labor inputs (respectively); $a_i = \frac{A_i p_y}{p_k^{\alpha_k} p_l^{\alpha_l}}$ is a price-adjusted technological term.

The log-linear version of the production function is:

$$\ln\left(y_i\right) = \ln\left(a_i\right) + \alpha_k \ln\left(k_i\right) + \alpha_l \ln\left(l_i\right) + \varepsilon_i. \tag{3}$$

Under the static moral hazard theory, hidden actions captured by the error term ε_i are influenced by the incentive power of the land contract. Dummy variables for each contract are then introduced into the model. Define $d_{o,i}$ as the ownership dummy (equals 1 if plot i is owned and 0 otherwise), $d_{f,i}$ as the fixed-rent dummy (equals 1 if plot i is rented and 0 otherwise), and assume that:

$$\varepsilon_i = \delta_o d_{o,i} + \delta_f d_{f,i} + u_i, \tag{4}$$

where δ_o and δ_f are parameters and u_i is a random shock capturing unobserved variables.

From (3)-(4), one has:

$$\ln(y_i) = \delta_o d_{o,i} + \delta_f d_{f,i} + \alpha_k \ln(k_i) + \alpha_l \ln(l_i) + \ln(a_i) + u_i. \tag{5}$$

The parameters δ_o and δ_f represent the mean effect of each contract form on $\ln(y_i)$ relative to the omitted contract dummy (i.e., sharecropping). The standard moral hazard theory (see Stiglitz, 1974; Holmström, 1979; and Grossman and Hart, 1983) predicts that owners and fixed-rent tenants are equally productive and strictly more productive than sharecroppers (i.e., $\delta_o = \delta_f > 0$). Alternatively, theories based on perfect monitoring (see Cheung, 1969) and on infinite-repeated games (see Rubinstein and Yaari, 1983; and Radner, 1985) predict that lands under ownership, fixed rent, and sharecropping are equally productive (i.e., $\delta_o = \delta_f = 0$). One can now test for these predictions.

4.1 OLS Estimates

If the unobservabilities captured by u_i are not privately observed by landlords or tenants, the endogenous covariates will be independent of u_i and, then, the ordinary least square (OLS) estimator will consistently identify the parameters in (5).[9] Otherwise, endogenously chosen variables (such as inputs and land contract) will be correlated to the error term, biasing the OLS estimator.

Table 4 summarizes the OLS results. Fixed effects for farmers in each period (year and season) are used in order to control for unobserved heterogeneity in farmer ability and to make results comparable to Shaban (1987).[10] Robust Huber-White standard errors are computed to account for the fact that households, rather than plots, are the primary sampling unit. The regression in column (a) does not control for land characteristics and type of crop grown, while the regression in column (b) does. Land value, irrigation, soil type, and main crop account for about half of the

[9] See Zellner, Kmenta, and Drèze (1966); Hodges (1969); and Mundlak (1996).

[10] Very similar results are obtained in regressions without fixed effects.

productivity advantage of owned lands. Similarly to Shaban, the owned plots of each given farmer are about 23% more productive than their sharecropped fields, after controlling for land characteristics.[11] Lands under fixed rent are not significantly more productive than lands under sharecropping.

The regressions in columns (c) and (d) introduce nonlabor and labor inputs as control variables. Since these inputs are strongly correlated, they are introduced separately. (They will be considered together in the estimation of the production function in Section 6.) Conditional on input use, the productivity advantage of owned lands becomes statistically non-significant, which indicates that owned lands are more productive because they use inputs more intensively.

[Table 4]

There are three key messages from these preliminary OLS regressions. First, since land quality is heterogeneous across farms under different contracts, one must be careful when interpreting differences in farm productivity as evidence of incentive problems. Land quality is not perfectly measured by variables such as the land value, irrigation, and soil type.[12] Therefore, regressing farm productivity on contract dummies—like in columns (a)-(b)—generates upward biased estimates for the coefficient of the contract form associated with the better lands (in this case, ownership). Second, the productivity disadvantage of share contracts is fully explained by observed variables (namely, inputs), which does not support the existence of hidden actions (i.e., actions that affect productivity and cannot be inferred from observed variables). Finally, these regressions indicates that one must understand the input choices, since they are strongly related to the productivity difference across land contracts. This is pursued in the next section.

5 Efficient Input Use

Owner-operated farms use nonlabor and labor inputs more intensively (see Table 3) and this difference in input use explains the productivity advantage of the ownership contract over sharecropping and fixed rent (see Table 4). However, since land quality is heterogeneous and imperfectly measured, this evidence is not sufficient to indicate existence of incentive problems. I develop here a structural model to test the efficiency of input allocation across farms under different contracts. The

[11] Shaban uses a linear regression model estimated in first difference and finds that the owned plots of each mixed tenant are, on average, 32% more productive than their sharecropped fields (see Shaban, 1987; Table 3, pp. 907).

[12] Land value, for instance, also reflects non-productive features such as proximity to the village.

method is based on profit-maximization conditions and is robust to heterogeneity in land quality and household characteristics.

Consider the problem of a central planner (or landlord) who chooses the amount of nonlabor and labor inputs to be used in each plot.[13] In a competitive environment, the planner shall maximize the expected added value (or profit). Moreover, in the absence of externalities, this maximization could be taken at the plot level. In this scenario, the efficient level of each input must solve:

$$\max_{k_i,l_i} E\left\{a_i k_i^{\alpha_k} l_i^{\alpha_l} \exp\left(\varepsilon_i\right) - k_i - l_i\right\}. \tag{6}$$

The necessary and sufficient first-order conditions are:

$$E\left\{\alpha_k a_i k_i^{\alpha_k - 1} l_i^{\alpha_l} \exp\left(\varepsilon_i\right)\right\} = 1, \tag{7}$$

$$E\left\{\alpha_l a_i k_i^{\alpha_k} l_i^{\alpha_l - 1} \exp\left(\varepsilon_i\right)\right\} = 1. \tag{8}$$

These conditions can be rewritten as:

$$E\left\{\frac{k_i}{y_i}\right\} = \alpha_k, \tag{9}$$

$$E\left\{\frac{l_i}{y_i}\right\} = \alpha_l. \tag{10}$$

It is worth stressing that the first-order conditions must be satisfied regardless of differences in land quality and farmer ability. Plots with more of these factors should increase input use up to the point at which marginal productivity equals marginal cost. Hence, if inputs are optimally chosen, these conditions should be constant across plots under different contracts. On the other hand, if tenants had a different objective function, this should be reflected in their marginal conditions. I then use a linear model for (9)-(10), where differences in marginal productivity are captured by contract dummies:

$$\frac{k_i}{y_i} = c_{1,k} d_{o,i} + c_{2,k} d_{f,i} + \alpha_k + \eta_{k,i}, \tag{11}$$

$$\frac{l_i}{y_i} = c_{1,l} d_{o,i} + c_{2,l} d_{f,i} + \alpha_l + \eta_{l,i}. \tag{12}$$

If farmers under different contracts chose inputs efficiently, one should have $c_{1,k} = c_{2,k} = c_{1,l} = c_{2,l} = 0$. These equations can be consistently estimated by OLS.[14] Table 5 presents the results. Regressions (a1) and (b1) consider the scenario

[13] Long-term investments are not studied here. The use of bullocks and machineries are measured by their rental value.

[14] Note that measurement errors in the variables are likely to be exacerbated by this type of test in which the dependent variable is a ratio of two variables.

where α_k and α_l are fixed for plots growing different crops and (a2) and (b2) control for the main crop. The contract dummies are statistically equal to zero in both scenarios, so that the null hypothesis of efficient input use cannot be rejected. The type of complementarity between land quality and other inputs that is inherent in the Cobb-Douglas production function is able to justify sharecroppers' input choices as optimal.

[Table 5]

6 Production Function Estimation

The results from Sections 4 and 5 show that: (i) the productivity advantage of owner-operated plots is essentially due to the input choices; and (ii) inputs were optimally chosen by farmers under different land contracts. From the profit-maximization conditions (7)-(8), the optimal amount of nonlabor and labor inputs are given by:

$$k_i^* = \left(\alpha_k^{1-\alpha_l}\alpha_l^{\alpha_l}a_i\theta_i\right)^{\frac{1}{1-\alpha_k-\alpha_l}}, \quad (13)$$

$$l_i^* = \left(\alpha_l^{1-\alpha_k}\alpha_k^{\alpha_k}a_i\theta_i\right)^{\frac{1}{1-\alpha_k-\alpha_l}}, \quad (14)$$

or equivalently:

$$\ln(k_i^*) = \frac{1}{1-\alpha_k-\alpha_l}\left(\ln(\alpha_k^{1-\alpha_l}\alpha_l^{\alpha_l}) + \ln(a_i) + \ln(\theta_i)\right), \quad (15)$$

$$\ln(l_i^*) = \frac{1}{1-\alpha_k-\alpha_l}\left(\ln(\alpha_l^{1-\alpha_k}\alpha_k^{\alpha_k}) + \ln(a_i) + \ln(\theta_i)\right), \quad (16)$$

where $\theta_i = E(\exp(\varepsilon_i))$ represents the land characteristics and shocks that are privately anticipated by farmers.

Note that θ_i is constant whenever farmers have no private information about ε_i. In this case, controlling for inputs would be unnecessary since $\ln(k_i^*)$ and $\ln(l_i^*)$ would be expressed as a linear combination of $\ln(a_i)$ and a constant. However, if farmers have access to private information regarding land quality, the input choices will reveal it. In this case, the OLS regressions in Section 4 do not identify the input coefficients and one must re-estimate the production function (5) imposing the profit-maximization conditions (7)-(8) as restrictions (see Greene, 2003). This procedure is appropriated here, once it has been shown that owners' and tenants' input choices satisfy conditions (7)-(8).

Table 6 presents the estimates. Regression (a) uses no fixed effect and (b) includes fixed effects for farmers in each period (year and season). The contract form does not affect land productivity, confirming the results from Section 4.

[Table 6]

7 Mixed Owner-Sharecropper Subsample

In order to check the robustness of the results, this section investigates the subsample of 2,833 plots cropped by households who have owned and sharecropped plots in each particular year and season (and who had no plot under fixed rent in that period). This subsample is defined in the same way as in Shaban (1987). There are 411 farmer-observations here, rather than the 329 farmer-observations in Shaban, because I have a few more years in my data set.[15]

I have run all previous regressions and obtained qualitatively identical results. In Table 7, I report the estimates of the production function without inputs and with inputs subject to the profit-maximization conditions (similarly to Tables 4 and 6). As before, the productivity gap between owners and sharecroppers is significantly reduced when observed land characteristics are introduced into the regression and vanishes when inputs are considered. Next, Table 8 reports the profit-maximization conditions across owned and sharecropped lands. The results are identical to those from Table 5—the null hypothesis that sharecroppers' input choices are not distorted is not rejected.

[Table 7-8]

8 Conclusion

This paper uses tenancy data from India to test the existence of missing incentives in one of the classic examples of moral hazard: the landlord-tenant relationship. I first investigate how the expected per acre output is affected by the tenancy contract. Sharecroppers are less productive than owners, but as productive as fixed-rent tenants. The productivity gap between owners and both types of tenants is driven by observable land quality and input use. Second, the profit-maximization conditions are used to test for underutilization of inputs. Even though there are many different reasons that would lead owners and tenants to maximize different objective functions, the empirical test does not reject the null hypothesis that their input

[15] The term "farmer-observation" refers to a farmer in a certain period (year and season).

choices satisfy the same marginal conditions. Next, I estimate the production function imposing the profit-maximization conditions to account for input endogeneity. No productivity difference across lands under ownership, fixed rent and sharecropping is found. Finally, when studying the subsample of sharecroppers who also own lands in the same period, I found no productivity differences between owned and sharecropped farms of each household. These results challenge the conventional wisdom that share contracts reduce incentives for optimal production decisions.

References

[1] **Allen, Douglas W. and Lueck, Dean.** "Contract Choice in Modern Agriculture: Cash Rent versus Cropshare." *Journal of Law and Economics*, October 1992, 35 (2), 397-426.

[2] **Allen, Douglas W. and Lueck, Dean.** "Transaction Costs and the Design of Cropshare Contracts." *RAND Journal of Economics*, Spring 1993, 24 (1), 78-100.

[3] **Bandiera, Oriana.** "Land Tenure, Incentives and the Choice of Production Techniques in Rural Nicaragua." Mimeo, London School of Economics, 2002.

[4] **Banerjee, Abhijit, Gertler, Paul and Ghatak, Maitreesh.** "Empowerment and Efficiency: Tenancy Reform in West Bengal." *Journal of Political Economy,* April 2002, 110 (2), 239-280.

[5] **Braido, Luis H.B.** "Insurance and Incentives in Sharecropping." In *"Insurance: Theoretical Analysis and Policy Implications,"* edited by P.A. Chiappori and C. Goulier, MIT Press, Cambridge, USA, 2005, forthcoming.

[6] **Cheung, Steven N.S.** *"The Theory of Share Tenancy."* University of Chicago Press, Chicago, USA, 1969.

[7] **Cheung, Steven N.S.** "Sharecropping." In *"Famous Fables of Economics: Myths of Market Failures,"* edited by D.F. Spulber, Blackwell Publishers Ltd., Oxford, UK, 2002.

[8] **Dubois, Pierre.** "Moral Hazard, Land Fertility and Sharecropping in a Rural Area of the Philippines." *Journal of Development Economics,* June 2002, 68 (1), 35-64.

[9] **Greene, Willian H.** *"Econometric Analysis."*, 5th Edition, Prentice-Hall, Englewood Cliffs, USA, 2003.

[10] **Grossman, Sanford J. and Hart, Oliver D.** "An Analysis of the Principal-Agent Problem." *Econometrica*, January 1983, 51 (1), 7-45.

[11] **Hodges, Dorothy J.** "A Note on Estimation of Cobb-Douglas and CES Production Function Models." *Econometrica*, October 1969, 37 (4), 721-725.

[12] **Holmström, Bengt R.** "Moral Hazard and Observability." *Bell Journal of Economics*, Spring 1979, 10 (1), 74-91.

[13] **Jacoby, Hanan G., Li, Guo, and Rozelle, Scott.** "Hazards of Expropriation: Tenure Insecurity and Investment in Rural China." *American Economic Review*, December 2002, 92 (5), 1420-1447.

[14] **Jacoby, Hanan G. and Mansuri, Ghazala.** "Incomplete Contracts and Investment: A Study of Land Tenancy in Pakistan." Mimeo, World Bank, 2002.

[15] **Jodha, N.S., Asokan, M. and Ryan, J.C.** "Village Study Methodology and Resource Endowment of the Selected Villages in ICRISAT's Village Level Studies." Economics Program Occasional Paper no. 16. Hyderabad: International Crops Research Institute for Semi-Arid Tropics, 1977.

[16] **Jodha, N.S.** "Agricultural Tenancy: Fresh Evidence from Dryland Areas in India." *Economic and Political Weekly*, December 1981, 16 (52), A118-A128.

[17] **Johnson, D. Gale.** "Resource Allocation under Share Contracts." *Journal of Political Economy*, April 1950, 58 (2), 111-123.

[18] **Laffont, Jean-Jacques and Matoussi, Mohamed S.** "Moral Hazard, Financial Constraints and Sharecropping in El Oulja." *Review of Economic Studies,* July 1995, 62 (3), 381-399.

[19] **Mundlak, Yair.** "Production Function Estimation: Reviving the Primal." *Econometrica,* March 1996, 64 (2), 431-438.

[20] **Radner, Roy.** "Monitoring Cooperative Agreements in a Repeated Principal-Agent Relationship." *Econometrica*, September 1981, 49 (5), 1127-1148.

[21] **Radner, Roy.** "Repeated Principal-Agent Games with Discounting." *Econometrica*, September 1985, 53 (5), 1173-1198.

[22] **Rao, C.H. Hanumantha.** "Uncertainty, Entrepreneurship, and Sharecropping in India." *Journal of Political Economy*, May-June 1971, 79 (3), 578-595.

[23] **Ray, Debraj.** *"Development Economics."* Princeton University Press, Princeton, USA, 1998.

[24] **Rubinstein, Abreu and Menahem E. Yaari.** "Repeated Insurance Contracts and Moral Hazard." *Journal of Economic Theory*, June 1983, 30 (1), 74-97.

[25] **Shaban, Radwan A.** "Testing between Competing Models of Sharecropping." *Journal of Political Economy*, October 1987, 95 (5), 893-920.

[26] **Singh, R. P., Binswanger, and Jodha, N.S.** "Manual of Instructions for Economic Investigators in ICRISAT's Village Level Studies." Technical Report, International Crops Research Institute for Semi-Arid Tropics, May 1985.

[27] **Stiglitz, Joseph E.** "Incentives and Risk Sharing in Sharecropping." *Review of Economic Studies*, April 1974, 41 (2), 219-255.

[28] **Walker, T.S. and J.G. Ryan.** "Village and Household Economies in India's Semi-Arid Tropics." Johns Hopkins University Press, 1990.

[29] **Zellner, Arnold, Kmenta, Jan and Drèze, Jacques H.** "Specification and Estimation of Cobb-Douglas Production Function Models." *Econometrica*, October 1966, 34 (4), 784-795.

Table 1. Data Description

Variable	Description
Output (per acre)	Value of main output and byproducts per area cropped (in Rupees per acre, R$/acre)
Ownership Dummy	1 if plot is owned (83.2%); 0 otherwise
Fixed-Rent Dummy	1 if plot is rented on a fix-rent basis (1.9%); 0 otherwise
Nonlabor Input (per acre)	Per acre value of seeds, fertilizers, pesticides, organic and inorganic manures, plus the rental value of bullocks and machinery (in R$/acre)
Labor Input (per acre)	Per acre value of family and hired labor (in R$/acre)
Land Value (per acre)	Per acre value of the plot (in 100R$/acre) estimated by ICRISAT's investigator using information about potential sale value, topography, location, etc., obtained from a village specialist
Irrigation Dummy	1 if the plot is irrigated (31.8%)
Soil-Type Dummies	7.1% deep black; 34.3% medium black; 21.7% shallow black; 11.1% shallow red; 2.4% gravelly; .5% problem soil (saline, etc.); 9.8% sandy soil; 1.1% other soils; 12% undefined
Cropping Pattern	Qualitative variable (with 1,031 different codes) describing all products cropped in each plot
Main-Crop Dummies	Dummy variables constructed from the first letter of the cropping pattern code (which describes a general category for the dominant cropping product): 16.8% oilseeds; 53.2% cereals; 9.3% fiber crops; .4% garden crops; 14% pulses; .8% sugar cane; 4.2% vegetables and spices; 1.3% fodder crops
Village Dummies	14.4% Aurepalle; 5.5% Dokur; 20.2% Shirapur; 15.7% Kalman; 14.6% Kanzara; 5.6% Kinkheda; 8.7% Boriya; 15.3% Rampura
Year Dummies	1975 (10.9%); 1976 (11.1%); 1977 (10.3%); 1978 (9.7%); 1979 (9.5%); 1980 (9.2%); 1981 (10.6%); 1982 (9.9%); 1983 (9.5%); 1984 (9.3%)
Season Dummies	35.8% planted from June to October; 58.5% from November to February; 5.5% from March to May; .2% perennial crops

Note: Data from the PS files of the Village Level Studies of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT).

Table 2. Summary Statistics

Variable	Mean	Min.	Max.	St. Dev.	Sample Size
Output (per acre)	754.1	.68	24,964	1,106	10,704
Nonlabor Input (per acre)	318	0	16,478.8	507.2	10,704
Labor Input (per acre)	150	.29	3,064	181.6	10,704
Land Value (per acre)	34	0	160	24.6	10,704

Note: Data from the ICRISAT's Village Level Studies.

Table 3. Conditional Mean Across Land Contracts

OLS

	Log Output (per acre) (a)	Log Land Value (per acre) (b)	Log Nonlabor Input (per acre) (c)	Log Labor Input (per acre) (d)
Ownership Dummy	**.42***	**.17***	**.43***	**.41***
Robust t-Statistic	(5.48)	(4.19)	(6.29)	(5.97)
Robust Std. Err.	(.08)	(.04)	(.07)	(.07)
Fixed-Rent Dummy	-.03	-.07	.08	.05
Robust t-Statistic	(-.21)	(-1.25)	(.78)	(.52)
Robust Std. Err.	(.15)	(.06)	(.11)	(.10)
Constant and Dummies for Village, Year, and Season	Yes	Yes	Yes	Yes
Sample Size	*10,704*	*10,702*	*10,690*	*10,704*
R^2	***.27***	***.60***	***.38***	***.38***

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. The robust Huber-White standard errors use 275 household clusters.

Table 4. Land Productivity

OLS with Farmer-Period Fixed Effects

	Log Output (per acre)			
	(a)	**(b)**	**(c)**	**(d)**
Ownership Dummy	**.47*****	**.23*****	.07	-.01
Robust t-Statistic	(4.15)	(3.45)	(1.52)	(-.39)
Robust Std. Err.	(.11)	(.07)	(.05)	(.04)
Fixed-Rent Dummy	.12	.03	-.04	-.07
Robust t-Statistic	(.82)	(.23)	(-.47)	(-.95)
Robust Std. Err.	(.14)	(.12)	(.08)	(.07)
Log Nonlabor Input (per acre)			**.61****	
Log Labor Input (per acre)				**1.0*****
Log Land Value (per acre)		**.43*****	**.27*****	**.19*****
Dummies for Irrigation, Soil Type, and Main Crop	No	Yes	Yes	Yes
Fixed Effects (households in each village, year, and season)	Yes	Yes	Yes	Yes
Sample Size	*10,704*	*10,702*	*10,688*	*10,702*

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. All regressions include a constant term and 2,773 fixed effects based on the household identification code for each village, year, and season. The robust Huber-White standard errors use 275 household clusters.

Table 5. Profit-Maximization Conditions

OLS

	Nonlabor Input / Output		Labor Input / Output	
	(a1)	**(a2)**	**(b1)**	**(b2)**
Ownership Dummy	.01	-.01	.01	.02
Robust t-Statistic	(.20)	(-.26)	(.70)	(.86)
Robust Std. Err.	(.05)	(.05)	(.02)	(.02)
Fixed-Rent Dummy	.30	.32	.09	.11
Robust t-Statistic	(1.19)	(1.33)	(1.15)	(1.42)
Robust Std. Err.	(.25)	(.24)	(.08)	(.08)
Main-Crop Dummies	No	Yes	No	Yes
Constant	**.72***	Yes	**.36***	Yes
Sample Size	*10,704*	*10,704*	*10,704*	*10,704*

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. The robust Huber-White standard errors use 275 household clusters.

Table 6. Production Function

Restricted OLS

	Log Output (per acre)	
	Without Fixed Effects	**Farmer-Period Fixed Effects**
	(a)	**(b)**
Ownership Dummy	-.03	-.04
Robust t-Statistic	(-1.12)	(-1.27)
Robust Std. Err.	(.03)	(.04)
Fixed-Rent Dummy	-.10	-.08
Robust t-Statistic	(-1.10)	(-1.08)
Robust Std. Err.	(.09)	(.08)
Log Nonlabor Input (per acre) Restriction: $\alpha_k = E(k_i/y_i)$	**.74*****	**.74*****
Log Labor Input (per acre) Restriction: $\alpha_l = E(l_i/y_i)$	**.38*****	**.38*****
Log Land Value (per acre)	**.18*****	**.16*****
Constant and Dummies for Irrigation, Soil Type, and Main Crop	Yes	Yes
Dummies for Village, Year and Season	Yes	No
Fixed Effects (households in each village, year, and season)	No	Yes
Sample Size	*10,688*	*10,688*

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. Regression (b) includes 2,773 fixed effects based on the household identification code for each village, year, and season and (c) includes 5,109 fixed effects based on the plot identification code for each village. The robust Huber-White standard errors use 275 household clusters.

Table 7. Land Productivity (Mixed Owner-Sharecropper)

OLS with Farmer-Period Fixed Effects

	Log Output (per acre)		
	(a)	**(b)**	**(c)**
Ownership Dummy Robust t-Statistic Robust Std. Err.	**.44***** (4.25) (.10)	**.22***** (3.73) (.06)	-.03 (-.81) (.04)
Log Nonlabor Input (per acre) Restriction: $\alpha_k = E(k_i/y_i)$			**.74*****
Log Labor Input (per acre) Restriction: $\alpha_l = E(l_i/y_i)$			**.38*****
Log Land Value (per acre)		**.38*****	**.14****
Dummies for Irrigation, Soil Type, and Main Crop	No	Yes	Yes
Constant and Fixed Effects (households in each village, year, and season)	Yes	Yes	Yes
Sample Size	*2,833*	*2,831*	*2,830*

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. All regressions include a constant term and 411 fixed effects based on the household identification code for each village, year, and season. The robust Huber-White standard errors use 102 household clusters.

Table 8. Profit-Maximization Conditions (Mixed Owner-Sharecropper)

OLS

	Nonlabor Input / Output		Labor Input / Output	
	(a1)	**(a2)**	**(b1)**	**(b2)**
Ownership Dummy	.13	.02	.02	.03
Robust t-Statistic	(.20)	(.41)	(.41)	(.86)
Robust Std. Err.	(.10)	(.05)	(.05)	(.03)
Main-Crop Dummies	No	Yes	No	Yes
Constant	**.67***	Yes	**.35***	Yes
Sample Size	*2,833*	*2,833*	*2,833*	*2,833*

Note: The asterisks ***, **, and * denote significance at a 1%, 5%, and 10% level, respectively. The robust Huber-White standard errors use 102 household clusters.