Inefficiency of tenancy contracts:

The role of imperfect monitoring, cost sharing

and crop composition

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Abstract

In this paper, we reconsider the question whether there is evidence for the so-called Marshallian inefficiency in real world sharecropping contracts or not. By extending the well known method of comparing the owned and sharecropped plots of owner-sharecroppers, we include variables controlling for the different crop types grown on owned and sharecropped plots as well as variables capturing the characteristics of the share contract. It turns out that in the naïve model, which does not account for the possible endogeneity of the crop choice, no evidence for the Marshallian inefficiency can be found, whereas in the model which assumes an endogenous crop choice process, there is support for the assumption that the actions of the tenant cannot be perfectly monitored.

1 Introduction

One of the crucial assumptions in most of the models dealing with the choice of contractual form in the market for tenancies in developing countries is whether the landlord can perfectly (costlessly) monitor the actions taken by his tenant. Under the assumption of prohibitively high costs of monitoring the tenant's activities, the so called 'Marshallian' approach, the theory predicts that the choice of a sharecropping contract will result in an inefficiently low amount of variable inputs applied to the rented land by the tenant, compared to the amount of variable inputs employed on owned land or on plots leased in under a fixed rent contract. If, in contrast, the landlord is able to effectively monitor the tenant's acitivities, as is assumed under the so called 'monitoring' approach, then the efficient amount of variable inputs per unit area can be stipulated in the contract, and there are no incentive problems to be dealt with, so that the cultivation of a plot under a share lease causes no inefficiencies compared with ownership cultivation or cultivation under a fixed rent lease. Since the predictions of the theory concerning such issues as the reasons for the existence of sharecropping arrangements and the efficiency of sharecropping depend crucially on the assumption whether perfect monitoring is possible or not (as well as on the assumptions describing the agents' risk taking behavior), and since it cannot be settled theoretically which of the two modelling approaches does more justice to the real world, it is essential to take a closer look at the empirical evidence.

This is far from being the first paper to investigate this question. An overview of the older existing literature is given by Hayami and Otsuka (1993), among the older contributions Shaban (1987) deserves special attention, and more recent work on the topic includes Raha (1991), Bell, Raha and Srinivasan (1995), and Acharya and Ekelund (1998).

In comparing the rates of difference in output per hectare of sharecropping from that of owner farming of 32 studies on the productive inefficiency of share contracts, Hayami and Otsuka (1993) find that the mean rate of difference for the studies where the comparisons are made in terms of single-crop output is not significantly different from zero, whereas if the comparisons are based on total output per hectare, the mean of the rates of differences is significantly different from zero in a direction which supports the Marshallian hypothesis. They state that in the latter case the distribution of the rates of differences is highly irregular, the irregularity stemming from differences in the production function due to differences in crop mix between sharecropping and owner-farming areas. They conclude that '...the significantly lower average output value per hectare for share-cropping than for owner-farming areas seems to reflect more of a difference in production functions than the existence of Marshallian inefficiency which refers to suboptimal labour input per hectare for the same production function'. The same argument holds for the comparisons of inputs.

To test whether the monitoring or the Marshallian hypothesis is valid, Shaban (1987) compares a family's average input and output intensities on owned and sharecropped land[1], an approach which controls for family-specific characteristics, such as management ability, access to non-traded inputs, risk aversion and prices of traded inputs and outputs. He regresses the differences of average input intensities on owned and sharecropped plots on plot-specific characteristics such as plot value, soil quality, and irrigation status, and on dummy variables for different villages. Using the plot-specific variables in the regression, he can test whether part of the differences in input and output intensities are attributable to these factors rather than the outcome of different incentives under owner cultivation and under share lease cultivation. The

[1] This comparison was first proposed by Bell (1977).

village dummies serve to proxy the variation in the cost-sharing rules across the villages, and thus have the function of capturing the effect on input and output differences which is caused by the contractual arrangement. Estimating a system of seemingly unrelated regression equations, Shaban finds empirical support for the Marshallian thesis.[2] Acharaya and Ekelund (1998) employ the same method as Shaban for a different data set, additonally controlling for crop variety and plot size, and also find evidence against the monitoring hypothesis.

A different approach is taken by Bell et al. (1995). They investigate whether the differences in resource allocation under share leases and self-cultivation are systematically related to the characteristics of the contracting parties. Their findings also favor the Marshallian hypothesis: In their study area, input intensities, yields and value added per hectare were all much lower on sharecropped than on owner-operated holdings, after controlling for sample selectivity in the choice of a contracting partner and differences in endowments, and even after ridding the data of fixed effects. But they also find that what they call 'matching' (finding a suitable partner to contract with) had the effect of alleviating the agency problems connected with a share lease, and that households made use of such matching to achieve an inprovement in contractual performance.

Analyzing a household survey of rice-cultivating farmers from the Philippines, Sadoulet, de Janvry and Fukui (1997) find evidence that supports their hypothesis that sharecroppers who have a kinship relationship with their landlord behave efficiently in applying the socially

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[2] Hayami and Otsuka (1993) suggest that the studies of Bell (1977) and Shaban (1987) represent strong evidence for the inefficiency of share tenancy under institutional constraints on tenancy choice rather than evidence for the inefficiency of share tenancy in general. See Hayami and Otsuka (1993), pp.101-102 for details.

optimum level of inputs and effort on their land, despite the disincentive effects caused by the sharing of output.

The aim of the present paper is to make a contribution to the existing literature in the following respects. First, I reestimate Shaban's model, using data from a survey of 14 villages in Andhra Pradesh, India. A novel feature of these data is that, for each sharecropping contract, they contain the accompanying cost-sharing rules, so that I do not have to rely on village dummies when aiming at measuring the effect of the contractual arrangement on input and output intensities. In an important extension of Shaban's model, I include crop dummies into the analysis. If one wants to compare an owner-sharecropper's performance on his owned and on his sharecropped plots, one has to average over the inputs and the output on all his sharecropped and on all his owned plots, with the side-effect that one also averages over different crop types. But this seems to be undesirable, since it is natural to assume that different crop types are produced with different technologies, as was already mentioned above. This fact would not cause a problem if all types of crops were grown in the same proportions on owned and sharecropped land. But if, as in this dataset, some crops are more extensively grown on sharecropped plots than on owned plots and vice versa, then not controlling for the crop type will lead to a distortion of the estimation results. In the light of this argument, Shaban's technique of using village dummies in order to control for the effect of share tenancy seems to be questionable, since instead of reflecting only the different cost-sharing rules across the villages, these dummies could just as well reflect different distributional pattern of crop types on owned and sharecropped plots between different villages. Indeed, I find that at least part of the differences between input intensities on owned and sharecropped land can be ascribed to different crops grown on these two arrangements.

I then extend my analysis of the differences between input intensities on owned and sharecropped plots to the class of owner-fixed-rent tenants in order to investigate whether there are also differences between input intensities under the latter pair of arrangements, and if there are differences, whether part thereof can be ascribed to the effects of tenancy, or whether the total differences can be explained by plot-specific factors or by different cropping patterns on owned and leased-in land. In this case, too, I find that different cropping patterns are one reason for different input intensities.

There is, however, a fundamental difficulty. If I employ indicator variables in the estimation for whether or not a crop is grown on a particular plot of a particular household, I encounter the problem that this set of crop dummy variables is not exogenously given, but is rather the result of an endogenous choice. If the choice of crops is endogenous and if the factors which determine it enter into the error terms in the estimation of the equations for the input differences (all unobserved household heterogeneity which influences owned and leased-in plots differently[3]), then not controlling for the endogeneity of crop choice will lead to inconsistent estimates for the parameters in the input-difference estimation. This presumption is confirmed by the data at least for the class of owner-sharecroppers: In the model which assumes that the crop variables are exogenous, the estimated coefficients for the crop dummy variables are highly significant, whereas the coefficients for the cost share variable are not significant at all. By contrast, in the model which takes into account the endogeneity of crop choice, the influence of

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[3] Two papers which deal with the influence of the tenant's and the landlord's characteristics on the choice of the crop type grown and on the choice of the contract form are Bandiera (2000) and Ackerberg and Botticini (2002). The latter find out that different landlords and tenants match on different crop types, since different crops show different degrees of riskiness.

the crop dummy variables becomes less significant, whereas a statistically significant influence of the cost share variables can now be detected.

The remainder of the paper is organized as follows: section two describes the data and contains some descriptive statistics; section three describes the estimation methods and discusses the results; and section four concludes the paper.

2 Description of the data

The data I use come from a survey which was canvassed between November 1980 and May 1982 in Andhra Pradesh, India, covering two kharif seasons and one rabi season.[4]

Next I present some summary statistics concerning the tenancy status and the operational landholdings of the households in the crop production schedule. There are 110 pure owner-cultivators, 37 owner-sharecroppers, 50 owner-tenants (farmers cultivating own land and having a fixed rent lease), 4 households cultivating own, sharecropped and land leased in under a fixed rent tenancy, 14 pure tenants, and only 1 pure sharecropper. Table 1 shows the average operational landholdings of households under different tenancy regimes. There are two things which attract attention: first, the own holdings of the owner-sharecroppers are smaller on average than their leased holdings, whereas for the owner-tenants this relation is the other way round. However, this difference is statistically significant only for the holdings of the owner-tenants (the p-value for the paired t-test is 0.0021 for the owner-tenants and 0.1862 for the owner-

[4] Exact information on how the survey was carried out can be found in Bell, Raha and Srinivasan (1995), who use data for the Punjab from the same survey.

sharecroppers)[5]. Comparing the own holdings of owner-sharecroppers with the own holdings of owner-tenants one observes that the latter are bigger than the former, the difference being significant at the 5 percent level (p-value 0.0416). The comparison of the leased-in holdings of owner-sharecroppers and owner-tenants yields the opposite picture: owner sharecroppers seemed to lease in on average larger amounts of land than owner-tenants, but the difference is not significant at conventional levels (p-value 0.1444). The second striking feature is the similiar 'farm size', i.e. the total operational landholdings, across the three different categories pure owners, owner-sharecroppers, and owner-tenants (the three respective hypotheses of equal farm sizes cannot be rejected). By leasing in and out land the households in the crop production schedule on average manage to reach an operational holding size between 4 and 4.5 acres which indicates that this amount of land represents something like an optimal farm size for a wide variety of circumstances. Of course, the exact individual farm size will depend on the particular household characteristics such as family labour, draught power, irrigation facilities, and risk taking behaviour. One may ask, why on average farmers with smaller own holdings end up with sharecropping contracts leasing in a larger amount of land than they own, whereas farmers with larger own holdings end up with fixed rent contracts, leasing in a smaller amount of land than they own by themselfves. One explanation for this pattern may be, that if tenants with larger own landholdings are also generally wealthier than tenants with smaller landholdings, and wealth can be seen as a proxy for the tenant's risk aversion[6], then theory predicts that more risk averse tenants will choose share contracts because these contracts serve as a risk sharing device, whereas

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[5]For all the following t-tests, non-parametric tests (Wilcoxon signed rank, Wilcoxon rank sums) yield the same results.

[6] See Ackerberg and Botticini (2002).

less risk averse or risk neutral tenants will end up with fixed rent contracts because they provide superior incentives from the landlord's point of view. Another explanation could be that sharecropping contracts are predominant in some districts, and leasing under fixed rent in others. If these districts show different climatical or environmental conditions, these conditions could be the reason for the different amounts of land owned and leased-in. In this sample, fixed rent contracts are predominant in the two mechanized villages which are fully irrigated by a canal system and in which almost solely paddy is grown. In the less mechanized and less irrigated villages sharecropping is the most frequent contract form. But is it hard to find an explanation why in a better irrigated environment households should lease in less land than in a sparsely irrigated environment.

The irrigation status of a plot will play a crucial role in the decision which crop should be grown on this particular plot, and therefore will have an influence on the amount of inputs applied. It will also influence the amount of output produced if the crop is sensitive to water scarcity. Table 2 describes the irrigation situation in the sample based on areas. On average 19 % of the area of the own holdings of owner-sharecroppers are irrigated, whereas on average 32 % of their sharecropped holdings are irrigated. Using a paired t-test, the hypothesis that these percentages are equal can be rejected at the 10% level. For the owner-fixed-renters, on average 48 % of their own holdings and 56 % of their leased-in holdings are irrigated. The hypothesis that these percentages are equal cannot be rejected.

Table 4 shows for each subgroup of land the percentages of land cultivated under different crops. From this table it is clear that paddy and groundnut are the crop types which are the main reason for the different cropping patterns on owned and sharecropped plots: 10 % of the owned land area is cultivated under paddy, whereas 26 % of the sharecropped area is under paddy cultivation. On the other hand, on 25 % of the owned area groundnuts are grown, whereas only on 12 % of the sharecropped land groundnuts are grown. In the case of cotton, 16 % of the sharecropped area is cultivated with cotton, but only on 5 % of the owned area cotton is grown. For the owner-fixed-renters, there is no remarkable difference between the crop types grown on owned and leased-in land.

Concerning the cropping patterns on owned and leased plots of the owner-tenants, one could argue that, apart from the physical characteristics of the plots, there is no reason why they should choose different cropping patterns on their owned and leased plots, for the landlord is not involved in the production process. Most of the fixed rents in this sample are paid in kind, however, so that the landlord should indeed have an interest in what kind of crop is cultivated on his leased-out plots. Since the owner-tenants have the best relation of irrigated to unirrigated plots for both leased and owned land, it seems to be natural that the main crop is paddy, whereas other less water-intensive crops are grown less frequently. In general, the cropping patterns on owned and leased-in plots for both types of tenants will depend on the endowment with production factors of both the landlord and the tenant.

Different cropping patterns on owned and shared plots will have an impact on the difference of average input intensities on owned and leased-in plots only if the technologies with which these crops are grown are different. To see whether this is the case or not, consider Table 4, where the mean input intensities for the most frequently grown crops in the crop production schedule are reported. At a first glance, one observes that it seems to be an untenable hypothesis that the different crops are produced with the same techniques. In order to support this observation statistically, I conducted F-tests for all six input categories which in all cases led to a rejection at the 1-percent level of the hypothesis that the mean input intensities are equal for all crops.

I conclude this section by emphasizing again that there are statistically significant differences between the cropping patterns on owned and shared land as well as between the mean input intensities employed in producing different crops. Ignoring this fact can lead to the omission of relevant variables (i.e. crop dummies) from the regression analysis.[7]

3 Estimation methods and empirical results

In this section I turn to the question of whether there are differences in the amount of inputs supplied per unit of land on owned field plots and plots cultivated under a tenancy, examining both share and fixed rent tenancies. This is done in subsection *3.1*. If there are differences, I investigate in subsection *3.2* whether these differences can be explained by factors which are different on owned and leased-in plots, such as irrigation status or the crop grown, or whether the difference or part of the difference can be attributed to incentive problems which are caused by the form of the tenancy contract. Since a potential problem arises in controlling for the crop type grown on plots of different tenancy status because the crop grown on a particular plot by a particular household may be the outcome of an endogenous choice process rather than exogenously given, I present in subsection *3.3* an econometric model which enables me to deal with this problem of endogeneity.

3.1 Comparison of average input intensities on owned and leased-in plots

Since each household in the subsample of owner-tenants has several owned and leased-in plots, I will make the comparison on the basis of the weighted averages of input intensities over the

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[7] Shaban (1987) is aware of this potential problem. To assess its importance, he conducts a regression analysis for those households which cultivated Sorghum only. He finds that there is still an effect of tenancy.

different plots, using the plot areas as weights.[8] There were two cultivation seasons in which a household could be observed to grow crops on his owned and leased-in plots, but not all households cultivated in both seasons. A household which cultivated in both seasons was dealt with as two separate observations, that is, I assume that the fixed effects for each household are independent of the season. It seems not too unrealistic to assume that, for example, the household's risk aversion and its managerial ability do not change from one cultivating season to the other. Thus, in this and the following sections there are 43 observations for households cultivating both owned and sharecropped plots, and 75 observations for households cultivating both owned plots and plots leased in against a fixed rent payment.

For the owner-sharecroppers I examine the differences in average input intensities for six input categories: seedlings, fertilizer and pesticides, farm yard manure, preharvest labour, harvesting labour, and bullock-pair days. In the case of owner-fixed-renters, there is the additional category 'tractor hours', since in contrast to sharecropping contracts, fixed-rent contracts are common in the two villages where tractors are used frequently instead of draught animals. The differences in average output intensities are also examined for both types of owner-tenants.

In order to take into account the possibility that the covariance between the differences in average input intensities for a given household is not necessarily equal to zero, I use the method of seemingly unrelated regression equations to regress the differences in average input intensities on owned and leased-in land on an intercept. The estimated covariance matrix is then used to

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[8] As long as I follow exactly Shaban's method of transforming the relevant variables, I will not give a detailed description of the computations. The interested reader is referred to Shaban (1987).

carry out a Wald test, the null hypothesis being that the differences in average input intensities are jointly equal to zero. The differences in average input and output intensities and the results of the t-tests are reported in table 5. For the owner-sharecroppers, the differences for seed, fertilizer and pesticides, farm yard manure, and harvesting labour are positive but not significantly different from zero, whereas the differences for preharvest labour and bullock pair days are negative but also not statistically different from zero. The mean difference in average output intensities is negative and not significant. Thus, looking at the mean differences for the particular inputs there is no evidence that these inputs are systematically undersupplied on sharecropped plots compared with owned plots. Following the predictions of the Marshallian theory there should be a positive sign for the mean difference in average output intensities, but there is a negative sign, leading one to the conclusion that if there are any negative incentive effects at work, then they are more than offset by other effects. Using the Wald test mentioned above, the hypothesis that all mean input differences are jointly equal to zero is rejected at the 1%-level ($\chi^2_{(6)} = 21.23$), indicating that there are effects which one should control for, determining systematically the mean input differences.

For the owned and leased-in plots of fixed-rent tenants the mean input differences are found to be jointly significantly different from zero at the 1%-level ($\chi^2_{(7)} = 67.13$). Since there is no theory which predicts that the input intensity on plots under a fixed-rent contract should be systematically higher than on owner cultivated plots, I will have to find out empirically by which factors this phenomenon can be explained.

3.2 Explaining the differences in average input and output intensities

In the preceding section I found the mean input differences for the owner-sharecroppers not to be individually different from zero, but the hypothesis that they are jointly equal to zero could be rejected at a high confidence level. This leads one to assume that there may be different effects, correlated for a particular household over the different inputs and working against each other, in determining the amount of a particular input applied to the household's own land and to its tenancy. On the other hand for the owner-fixed-renters the mean input differences are in most cases individually different from zero, which is unexpected, and has to be explained as well as the sign of the difference .

The aim of the following analysis is to identify the factors which systematically influence the differences in input intensities, and eventually to isolate the effects which can be ascribed to the contractual form under which a plot is cultivated. In his attempt to settle the question whether the actions of the tenant are perfectly monitorable or not, Shaban (1987) regresses the differences in average input and output intensities on plot-specific variables such as dummies for the soil type and the irrigation status of the plot, and on a set of village dummies which he such claims to be the only household-specific attributes that are expected to have a differential impact on input intensities on owned and sharecropped plots. He argues that the village dummy variables will partially reflect the variation in the cost sharing rules across the villages. But these village dummies may as well capture the variation in cropping patterns on owned and sharecropped plots across the villages. Instead of using village dummies, therefore, I employ as regressors the relation of the tenant's cost share to his output share and a dummy for whether the application of the respective input is supervised by the tenant alone or by both the landlord and the tenant. These two regressors will measure the pure effect of tenancy, since if one or both of these variables have an effect on the input differences, this means that the form of the particular contract influences the tenant's decision of how much of the respective input to supply. Additionally, I control for different cropping patterns on owned and sharecropped plots, using dummies for several crops which are frequently cultivated.

Using Shaban's (1987) notation, the equations to be estimated are derived as follows: Consider an owner-sharecropper cultivating *K* owned and *L* sharecropped plots with *n* variable inputs. The input intensities (per unit area) for each input category *i* on the owned and sharecropped plots are determined by the following equations:

$$x_{ik}^{o} = \alpha_i^{\ o} + g_i(Z) + \delta_i I_k + \sum_{m=1}^{M} \beta_{mi} C_{mk} + \gamma_{1i} S_i + \gamma_{2i} share_i + \varepsilon_i, \quad k = 1,....,K\,, \qquad (1)$$

$$x_{il}^{s} = \alpha_i^{\ s} + g_i(Z) + \delta_i I_l + \sum_{m=1}^{M} \beta_{mi} C_{ml} + \gamma_{1i}' S_i + \gamma_{2i}' share_i + \eta_i, \quad l = 1,....,L\,. \qquad (2)$$

Shaban defines the term $g_i(Z)$ as 'a function of deterministic and stochastic variables that have identical effects on the choice of intensity of input *i* on owned and sharecropped plots'. As examples of these variables he mentions family-specific shadow values of all inputs and outputs, its managerial ability, and a family's endowment of production resources, human capital, and labor resources. I_k and I_l are dummy variables which stand for whether the plot is irrigated or not, and the C_{mk} and C_{ml} are dummy variables for the *M* different crops which take on the value of one if a crop is cultivated on the respective plot, and are equal to zero otherwise. S_i is a household specific 'average' dummy variable the value of which is between zero and one, and is the closer to one the more closely the plots under tenancy are supervised by both the landlord and the tenant with respect to the input in question, that is $S_i = \frac{\sum_l s_{li} t_l}{\sum_l t_l}$, where the plot areas t_l are used as weights, and the s_{li} are the plot- and input-specific dummy variables which are equal to one if the supply of input *i* on plot *l* is supervised by both the landlord and the tenant, and zero otherwise. The variable $share_i$ is a household- (or contract-) specific variable which is defined as

$share_i = \frac{\sum_l cs_{li} t_l}{\sum_l t_l}$. The cs_{li} are the plot- and input-specific costshare to outputshare relations, that is, the cs_{li} are the empirical counterparts to $\delta = \frac{\beta}{\alpha}$ in the theoretical analysis in Steinmetz (2005). The error terms ε_i and η_i are, as Shaban puts it, 'the missing variables that affect owned and sharecropped plots differentially'. As already mentioned above, especially the characteristics of the tenant's landlord will be captured by these error terms. Under this specification, the error terms are assumed to be identical across different plots of the same tenure status for each household. It is assumed that the error terms have zero means and finite variances, but it is not assumed that there is zero correlation between the error terms of different input categories.

Because each household normally cultivates several owned and sharecropped plots, and because the comparison of input intensities cannot be done on the plot level (since it is not possible to assign a certain owned plot to a certain sharecropped plot), one has to somehow average over the different plots of the same tenure status of a given household. This averaging is done, again following Shaban, by using the plot areas as weights. Thus define:

$$\Delta x_i \equiv \frac{\sum_k x^o_{ki} t_k}{\sum_k t_k} - \frac{\sum_l x^s_{li} t_l}{\sum_l t_l}, \qquad I^o \equiv \frac{\sum_k I_k t_k}{\sum_k t_k}, \quad I^s \equiv \frac{\sum_l I_l t_l}{\sum_l t_l}, \quad C^o_m \equiv \frac{\sum_k C_{mk} t_k}{\sum_k t_k},$$

$$C^s_m \equiv \frac{\sum_l C_{ml} t_l}{\sum_l t_l}, \qquad \alpha_i \equiv \alpha^o_i - \alpha^s_i, \ \theta_{1i} \equiv \gamma_{1i} - \gamma'_{1i}, \ \theta_{2i} \equiv \gamma_{2i} - \gamma'_{2i}, \text{ and } \upsilon_i \equiv \varepsilon_i - \eta_i .$$

Then one can write the differences in average input intensities on owned and sharecropped plots for each household as

$$\Delta x_i = \alpha_i + \delta_i \left(I^o - I^s\right) + \sum_{m=1}^{M} \beta_{mi} \left(C^o_m - C^s_m\right) + \theta_{1i} S_i + \theta_{2i} share_i + \upsilon_i, \quad i = 1,....,n . \qquad (3)$$

The equation for the differences in average output intensities is similiar to equation (3) apart from the fact that instead of the supervision dummy, a dummy variable is used which is equal to one if the landlord decides on the cropping pattern on the respective plot, and which is equal to zero if the tenant decides on the cropping pattern. For this dummy variable, too, I take the average over all plots of the same tenancy status.

In the estimation equation for the differences in average input intensities on the owned and leased-in plots of fixed-rent tenants I drop the supervision dummy and the costshare variable since in all cases the input supply is supervised only by the fixed-rent tenants themselves, and the cost share to output share relation is always equal to one. Instead of these variables I include a dummy variable which is equal to one if the landlord is a friend or a relative of the tenant, and which is zero otherwise.[9] I also included a dummy variable to control for whether the rent is paid in kind after the harvest or not, but this variable was not significant in any of the input equations. Since, in contrast to sharecropping contracts, fixed-rent contracts are present in the two sample villages in which tractors are frequently used, there is an additional equation for the input category 'tractor hours'. In this equation I multiply each regressor with an interaction dummy which is equal to one if the observation is from the two villages where tractors are used, and zero otherwise. In this way, I take into consideration that the input 'tractor hours' is used only in these two villages. Further, I include an intercept village dummy in the equation for 'bullock-pair days'.

The *n* equations in (3) are estimated by seemingly unrelated regression (SUR), since it is reasonable to assume that the error terms of the same household are correlated with each other over the different input categories. This assumed correlation can be understood by the above

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[9] This relationship dummy was also employed in the estimation of equation (3), but in no case was it significant.

argument that the error terms capture the unobserved characteristics of the household which influence owned and sharecropped plots differently. The equation for the differences in average output intensities is estimated separately by OLS.

Tables 6 and 7 contain the estimation results for the SUR estimation for the six input categories for the cultivators of owned and sharecropped land and for the cultivators of owned and leased-in land, respectively. The OLS estimates for the two output equations are reported in the respective tables as well.

In table 6, consider first the estimates for the variable *cost share* itself: The coefficients have a negative sign for seed, farm yard manure, preharvest labour, and bullock pair days, and a positive sign for fertilizer and for harvest labour, but only the coefficients for seed and fertilizer are significant at conventional significance levels. The hypothesis that all coefficients are jointly equal to zero can be rejected at the 5% level ($\chi^2_{(6)} = 13.04$). Following the theoretical model in Steinmetz (2005), one should expect the signs of the coefficients for the cost share variables to be positive, since a higher cost share to output share relation for the tenant will induce the latter to supply less of the respective input according to the predictions of the theory. But there is only one positive coefficient which is significant at the 5% level, though. Thus there is only weak evidence that this particular contractual characteristic has an influence on the farmer's input decisions.[10] The hypothesis that all intercept coefficients are jointly equal to zero can be rejected at the 5% level. Testing the hypothesis that the coefficients for all crop dummies in all input equations are jointly equal to zero, the null hypothesis is rejected at the 1% level ($\chi^2_{(13)} = 152.67$). Additional

[10] The six cost-share variables were also included in the output equation, but none was found to be significant.

Wald tests to test the hypothesis whether the coefficients for all crop dummies in the same input equation are jointly equal to zero show the following results: for the input categories seed, farm yard manure, preharvest labour, and bullock pair days this hypothesis is rejected at the 1% level, for harvest labour it is rejected at the 5% level, and for the category fertilizer and pesticides it cannot be rejected. All this provides strong evidence that the crop mixture grown on different plots of the same tenancy status has in fact a non negligible effect on the differences in average input intensities.

According to the theory, one should include the cost-shares of the other inputs as regressors in the estimation equation for a certain input, but here one meets with the problem of multicollinearity, since in nearly all cases the cost-shares for different inputs are the same in a contract. Thus, it is not possible to test the hypotheses of positive cross-effects.

Another point on which I should remark is the relation between the supervision dummies and the cost share variables: One would expect cost-sharing to be highly correlated with supervision in order to avoid cheating by the tenant; that is, one would expect the supervision to be the closer, the higher the cost share of the landlord. I computed Pearson's correlation coefficient for the six cost-sharing variables and the five supervision dummies, which all had a negative sign as expected, but the correlation was significant only in four cases, twice at the 5% level (the bullock-pair days cost share with the supervision of bullock-pair days and seeds) and twice at the 10% level (the bullock-pair days cost share with the supervision of fertilizers and preharvest labour).

From these findings the answer to the initial question whether there is evidence in favor of the Marshallian hypothesis is not quite clear. The two variables which stand for two characteristics of the respective contract, the supervision dummy and the cost-share variable, are either not jointly significantly different from zero, as in the case of the supervision dummies, or they are not individually different from zero and have the wrong sign, as in the case of the cost-share variable. This implies that the tenant's decision of how intensely to supply inputs on his sharecropped plots is not, in general, influenced by the contractual arrangements concerning the supervision of the inputs, and is only weakly influenced by the contractual arrangements concerning the costs of the inputs. This in turn implies that the predictions of the theory under the assumption of imperfect monitoring are only weakly supported by the evidence of the present data set. There remains the fact that most of the intercepts are positive, and that they are jointly significantly different from zero at the 5% level. But since the data are lacking, I am not able to control for soil quality and plot value[11], two factors which can be different on owned and sharecropped plots, and which are likely to influence the input supply on both types of plots in the same way. Therefore I cannot interpret the positive intercept as the effect of tenancy alone without reservation. In the present data set, the differences in average input intensities seem to be explained mostly by different cropping patterns and by the different extent of irrigation on owned and sharecropped plots.

In table 7 the results for the owner-fixed-rent tenants are reported. The hypothesis that all intercept coefficients are jointly equal to zero is rejected at the 1% significance level ($\chi^2_{(7)} = 25.13$). The intercept in the output equation is negative and insignificant. The hypothesis that all irrigation coefficients in the seven input equations are jointly equal to zero can be rejected at the 1% level ($\chi^2_{(7)} = 38.69$). Because of the correlation between irrigated plots and plots

[11] Shaban controls for these variables and finds a significant influence on the differences in average input intensities.

cultivated under paddy, which is also in this case strongly positive[12], the irrigation dummy variable stands for irrigated paddy; that is, also for the plots of owner-fixed-rent tenants the significantly positive coefficients for the irrigation dummy variable can be interpreted to the effect that the higher the proportion of owned plots cultivated under irrigated paddy compared with the proportion of leased-in plots cultivated under irrigated paddy, the larger is the difference between average input intensities on owned and leased-in plots for the respective input. Testing some joint hypotheses on the coefficients of the crop dummies, I find the following: the cross-equations restriction that all crop coefficients are jointly equal to zero is rejected at the 1% level ($\chi^2_{(14)} = 198.75$), and the hypothesis that for each input category the coefficients of the included crop dummies are jointly equal to zero is rejected at the 1% level for seed, bullock labour, and harvest labour ($\chi^2_{(3)} = 49.63$, $\chi^2_{(3)} = 105.60$, and $\chi^2_{(2)} = 50.35$, respectively), at the 5% level for fertilizer ($\chi^2_{(2)} = 7.75$), and it cannot be rejected for preharvest labour ($\chi^2_{(3)} = 4.68$). In the output equation, the crop dummy for sugarcane and the irrigation dummy are highly significant. That is, the differences in average input intensities of cultivators of owned plots and plots leased in under a fixed-rent contract can also be explained partly by the differences in cropping pattern on owned and leased-in plots.

Noteworthy is the fact that the relationship dummy variable is negative for all seven input equations, and significantly so for seed at the 5% level, and for preharvest labour and for harvest labour at the 10% level. The hypothesis that the coefficients for the relationship variables in all seven input equations are jointly equal to zero is rejected at the 5% level ($\chi^2_{(7)} = 14.81$). Thus one

[12] Pearson's correlation coefficient is $\rho = 0.9331$, which is even higher than in the case of owner-sharecroppers.

can draw the conclusion that if the landlord is a friend or a relative of the tenant, this works to increase the latter's input supply on his leased-in plots compared to his owned plots. This result is a surprising one from a theoretical point of view, since theory predicts that in the case of a fixed-rent contract, the efficient input supply on the leased-in plots does not depend on the contracting parties' characteristics (the relationship to the landlord is a contract characteristic in a broader sense).

There is a theoretical argument by which a different input supply on the owned and leased-in plots of a fixed-rent tenant can be explained: If the contractual arrangement is such that the tenant has to make the fixed rent payment in kind after the harvest (which can be seen as a de facto production loan), then for a risk averse tenant who in the case of a crop failure will not be able to pay the rent there is a 'leverage' effect. This leverage effect is caused by the fact that in the case of a good harvest the tenant gets the whole surplus, whereas in the case of crop failure his loss is limited to his input costs. This effect can lead to a higher input supply on the leased-in plots. We included a dummy variable in all seven input equations and in the output equation to control for whether the rent is paid in kind after the harvest or in cash before, but the coefficients were not significant for any input category and not for output.

I conclude from these results that for the owned and leased-in plots of fixed-rent tenants, too, there are differences in the average input intensities which cannot be ascribed to different plot characteristics or to different cropping patterns on owned and leased-in plots. There are factors such as the relationship between the landlord and the tenant which are linked with the tenancy contract and which determine the amount of inputs supplied to the plots cultivated under this contract.

3.3 Endogenous crop choice

I have assumed so far that the cropping pattern and the characteristics of the individual contract were exogenously given. But this is not a very realistic assumption, since the decision of which crop to cultivate as well as the fixing of the contractual parameters such as the cost-share will probably be endogenously determined by the observed and unobserved characteristics of the tenant, and – where the plots under tenancy are concerned – by the observed and unobserved characteristics of the respective landlord. As was already mentioned, the error terms in equations (3) capture all unobserved heterogeneity among households which influences the average input intensity on owned and sharecropped or on owned and leased-in plots differently. Examples of this unobserved heterogeneity are the risk aversion of the tenant and the risk aversion of the related landlord, and all other characteristics of the landlord, since the characteristics of the landlord will almost certainly influence the tenant's input decision on his sharecropped-in or leased-in plots on the one hand and on his owned plots on the other hand differently. The problem which now arises is that the crop choice of the tenant and the agreement between the tenant and the landlord on the contractual parameters may be determined among other things by exactly these unobserved characteristics of the tenant and the landlord. Then the crop variables as well as the variables standing for the contract characteristics are correlated with the error term, with the consequence that the estimates for the related coefficients will be inconsistent. In the following, I will focus only on the endogeneity of the crop variables. Concerning the possible endogeneity of contract characteristics such as the cost share, who supervises the production process, and the relationship between the landlord and the tenant, one can argue based on evidence from the data set that the cost share used for a certain crop and a certain input is determined by its common use in the respective village rather than lying within the discretion of the landlord and the tenant. For the other two variables, the supervision and the relationship dummy, it is hard to find an argument against their endogeneity, but I will neglect it in order to not overload the following empirical analysis, which already suffers from data constraints.

The econometric model which takes into account the endogeneity of crop choice can be formulated as follows. The system of equations explaining the differences in average input intensities on owned and leased-in land of the two groups of tenants is still represented by the *n* equations in (3):

$$\Delta x_i = \alpha_i + \delta_i\left(I^o - I^s\right) + \sum_{m=1}^{M}\beta_{mi}\left(C_m^o - C_m^s\right) + \theta_{1i}S_i + \theta_{2i}share_i + \upsilon_i, \quad i = 1,....,n\,. \qquad (3)$$

Now, however, the crop dummies for the crops cultivated on owned and leased-in land, C_{mk} and C_{ml}, respectively, are no longer assumed to be exogenously given, but rather to be the outcome of some kind of agreement between the landlord and the tenant if the respective plot is cultivated under a tenancy, or to depend on the observed and unobserved characteristics of the tenant alone if the plot is under owner cultivation. Let the total number of plots an owner-sharecropper or an owner-fixed-rent-tenant cultivates be $Q = K + L$, $q = 1,...,Q$. Then C_{qhm} is a dummy variable which is equal to one if crop *m* is cultivated on plot *q* of household *h* ($h = 1,...,H$), and which is equal to zero otherwise. Now define the latent variable underlying the crop choice process, V_{qhm}, as the net benefit from growing crop *m* on plot *q* of household *h*. That is, the individual plot of a certain household cultivating both owned land and leased-in land will be the unit of observation in this crop choice model. Assume that the net benefit is given by

$$V_{qhm} = \beta_a' a_m + \beta_p' p_{qh} + \gamma_T' x_h + \gamma_L' J_{qh} y_{qh} + \delta J_{qh} + u_{qhm}\,, \qquad (4)$$

where a_m is the vector of characteristics of crop *m*, p_{qh} is the vector of characteristics of plot *q* of household *h*, x_h is the vector of characteristics of household *h*, J_{qh} is a dummy variable which is equal to one if plot *q* of household *h* is cultivated under a tenancy, and is equal to zero otherwise, y_{qh} is the vector of characteristics of the landlord belonging to plot q of household h if the plot is cultivated under a tenancy, and u_{qhm} refers to the effects of unobserved heterogeneity. Then the choice of crop m on plot q by household h can be described as follows:

$$C_{qhm} = 1 \qquad \text{if } V_{qhm} \geq V_{qhn} \quad \forall n \neq m\,,$$

$$C_{qhm} = 0 \qquad \text{otherwise.} \tag{5}$$

Equations (4) and (5) describe a multinomial logit model which will be estimated seperately for owner-sharecroppers and for owner-fixed-renters, using all owned and leased-in plots of the households I used in the estimations of equations (3) in section *3.2*. Employing the characteristics of the landlords belonging to a particular plot cultivated under a tenancy in the estimation, we meet with two problems. First, we do not know the characteristics of all landlords, since some of the landlords are not resident in the sample villages and therefore are not recorded in the census. Second, it is reasonable to assume that a particular tenant matches with a particular landlord dependent on their observed and unobserved characteristics[13]. Thus, the landlord's characteristics would then be endogenously determined variables which are potentially correlated with the error term. We deal with these problems by first using only the subset of tenants and landlords for which we know the characteristics of the landlords, regressing each particular landlord characteristic on all tenant characteristics[14]. Then we employ the estimated parameters from this regression to predict the characteristics of all landlords in the total sample of owner-tenants. That

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[13] See Bell, Raha, and Srinivasan (1995).

[14] Again the SUR method is used to estimate the system of equations which link the landlord characteristics with the tenant characteristics, since it is reasonable to assume that for each landlord the error terms are correlated over the different characteristic equations.

is, we take the tenant's characteristics as exogenously given and uncorrelated with the error term, using them as instruments to instrumentalize the endogenous landlord characteristics which we wish to use in the crop choice regression. At the same time, we obtain predicted values for the missing landlord characteristics. The question may arise whether the fact that the landlord is resident or not has a bearing on the choice of contract, for non-resident landlords may find it hard to supervise, and will therefore probably prefer to offer a fixed-rent contract. In table 10a the frequencies of absent landlords are reported for all tenants in the core transaction schedule. There is no evidence that the landlords of fixed-rent tenants are more often absent than the landlords of the sharecroppers: 27 % of the share tenants' landlords and 28 % of the fixed-rent tenants' landlords were absent. The hypothesis of equal proportions cannot be rejected ($\chi^2_{(1)} = 0.008$).

Putting these things together, the econometric model to be estimated is given by the following simultaneous-equations model:

$$\Delta x_i = \alpha_i + \delta_i\left(I^o - I^s\right) + \sum_{m=1}^{M} \beta_{mi}\left(C_m^o - C_m^s\right) + \theta_{1i}S_i + \theta_{2i}share_i + \upsilon_i, \quad i = 1,....,n \tag{9}$$

$$V_{qhm} = \beta_a' a_m + \beta_p' p_{qh} + \gamma_T' x_h + \gamma_L' J_{qh} y_{qh} + \delta J_{qh} + u_{qhm}, \tag{10}$$

$$C_{qhm} = 1 \qquad \text{if } V_{qhm} \geq V_{qhn} \quad \forall n \neq m,$$

$$C_{qhm} = 0 \qquad \text{otherwise,} \tag{11}$$

where V_{qhm} is the latent variable underlying the average crop dummy variables C_m^o and C_m^s, and where the error terms υ_i and u_{qhm} are correlated. Maddala (1983, pp.120-121) proposes a two-stage estimation method to estimate this kind model: First estimate equation (10) (in our case by a multinomial logit model), get the estimates of all parameters in (10), and derive the predicted probabilities for the crop choices. Then equation (9) can be estimated by SUR after substituting the predicted probabilities for the C_{qhm} underlying the C_m^o and C_m^s in (9).

Table 10 contains the estimation results for the multinomial logit estimation of the crop choices of owner-sharecroppers and owner-fixed-renters. There are seven crop categories for the owner-sharecroppers (paddy, cereals, grams, groundnut, cotton, castor seed, and others, including vegetables and chillies), and eight crop categories for the owner-fixed-renters (paddy, cereals, grams , groundnut, cotton, chillies, sugarcane, and others, including vegetables, castor seed, coconut, tabacco). The category 'others' contains in both cases the crops which were grown in only a few cases by the respective group of owner-tenants. We will not comment on each of the estimated coefficients, but some results are worth mentioning. First, there are not many landlord characteristics which have a statistically measurable influence on the crop choice. We included all landlord characteristics in both estimations which turned out to be at least significant at the 10% level for a particular crop in one of the estimations.[15] We also included a set of dummy variables for whether a particular plot is cultivated under a tenancy or not, but none of these coefficients was found to be significant at any conventional significance level in both estimations. An explanation for this could be that all the effects of tenancy are captured by the characteristics of the landlord and by the match between the landlord and the tenant. The coefficients for *famsizl.paddy* are positive and significant at the 10% level in both estimations, that is, for both owner-sharecroppers and owner-fixed-renters the size of the landlord's family has a positive influence on the probability that paddy is grown on a leased-in plot. This is what one would expect since paddy is the main food crop, and a larger family needs more of it. Also, a larger landlord family means that there are more persons who can monitor the tenants actions, an important task when paddy is concerned. The coefficients for *famlabml.paddy* are negative in

[15] Due to the not very large number of observations, it will not produce very convincing results if we include all possible regressors in the estimation.

both estimations, but only the coefficient in the owner-fixed-renters estimation is significant at the 5% level, whereas the coefficient for the owner-sharecroppers is just not significant at the 10% level. Thus, we find evidence at least for the owner-fixed-renters that the number of adult male workers in the landlord's family reduces the probability that paddy is grown on a leased-in plot. If a landlord has in his own family more workers to produce the relatively labour intensive crop paddy, he will be less interested in receiving his fixed rent payment in the form of paddy.[16] For the tenants the results for these paddy related coefficients are more puzzling. The number of adult male workers in an owner-sharecropper's family has a negative effect (significant at the 1% level) on the probability that paddy is cultivated on a plot (owned or sharecropped-in), and for the owner-fixed-rent tenants the respective coefficient is positive, but not significant at conventional significance levels. The total number of family members in an owner-sharecropper's family has a negative but not significant influence on the choice probability for paddy, whereas the respective coefficient is negative and highly significant for the owner-fixed-rent tenants. It is hard to find a convincing explanation for why the number of family members should induce a farmer to grow less of the main food crop on his owned and leased-in plots. Other variables of interest are the total asset values of the tenant and the landlord. These variables are potential proxy variables for the unobserved risk aversion of the tenant and the landlord. The coefficients of the asset variable for paddy, cereals, and grams are all (except the coefficient for *assett.cereals*) significant at least at the 10% level for both groups of tenants, indicating that the wealth of a tenant has an influence on his crop choice. In contrast, among the estimated *assetl.* coefficients for both groups of tenants only the coefficient for *assetl.grams* is significant at the 10% level. That is, there is only weak evidence that the landlord's wealth influences the cropping pattern on the plots under tenancy.

[16] In most cases the fixed rent is paid in kind, if paddy is grown under tenancy.

Summarizing, one can say that besides the tenant's characteristics, the landlord characteristics seem to have a non-negligible influence on the crop chosen on a particular plot cultivated under a tenancy.

The next step is to use the predicted probabilities for the crop choices in the SUR estimation of equations (9). The estimated parameters for the SUR estimation using the predicted probabilities are set out in tables 12 and 14 for owner-sharecroppers and owner-fixed-renters, respectively. In section *4.2* we used only the crop dummies in the regressions which we expected from tables 3-6 to have a noticeable influence on the differences in average input intensities, since we wanted to save degrees of freedom in order to obtain more precise estimates for the coefficients of interest. In this section, we use in the SUR regressions crop dummies for all the crop categories which were present in the multinomial logit estimation in order to maintain the consistency of the argument. Equations (9) were also reestimated using the actual values for the crop dummies for all crop categories in the multinomial logit model. This provides us with the benchmark with which we can compare the results from the estimations with the predicted crop dummies. The results of these estimations are set out in tables 11 and 13 for the owner-sharecroppers and the owner-fixed-renters, respectively. In the case of owner-sharecroppers we could not use the crop dummies for the categories 'castor seed' and 'others', since they turned out to be collinear with other crop dummies when using the predicted probabilities instead of the actual values.

Before turning to the testing of some hypotheses, something should be said about statistical inference in two-stage methods. It is incorrect to use the standard errors from the second stage of the two-stage procedure in judging whether or not the coefficients are significant, since this procedure ignores the fact that some of the explanatory variables are estimated.[17] For two-stage estimation of reduced-form equations, however, the standard errors for the second stage are normally not far off from the correct standard errors (see Maddala, 1983, p.238). In the following, we will use the standard errors from the second stage.

Comparing the two tables for the owner-sharecroppers, one can see that the parameter estimates for the irrigation dummies and for the supervision dummies do not change their signs, and that, in most cases, these estimates are as precise as those arising from the use of the actual crop dummies. There is, however, a change in the result of the test of one of the joint hypotheses. For the joint hypotheses that all coefficients for the irrigation dummies are jointly equal to zero there is no difference between the actual values and the predicted values estimation: In both cases the null hypothesis is rejected at the 1% level ($\chi^2_{(6)} = 41.21$ and $\chi^2_{(6)} = 38.13$, respectively). Testing the joint null hypotheses for the coefficients of the supervision dummies, one finds that the hypothesis cannot be rejected for the actual-values estimation ($\chi^2_{(6)} = 8.44$), whereas it is rejected at the 5% level ($\chi^2_{(6)} = 15.04$) for the predicted-values estimation. That is, controlling for the endogeneity of the crop choice, we can now reject the hypothesis that there is no influence of the supervision arrangement on the differences in average input intensities. For the intercepts there are some changes in the signs and in the significance levels, but the joint null hypotheses are rejected at the 5% level for both the actual-values and the predicted-values estimation ($\chi^2_{(6)} = 13.05$ and $\chi^2_{(6)} = 15.65$, respectively).

However, there are quite a lot of changes in the signs as well as in the levels of significance of the parameter estimates for the crop dummies and for the cost-share variables.

[17] See Pagan (1984) for a detailed discussion of this problem.

Again carrying out some joint hypotheses tests, we find that for the estimation which uses the predicted crop dummies the hypothesis that all cost-share coefficients are jointly equal to zero can now be rejected at the 1% level ($\chi^2_{(6)} = 23.57$), whereas for the estimation using the actual crop dummies it could only be rejected at the 10% level ($\chi^2_{(6)} = 12.31$). Controlling for the endogeneity of the crop choice has the consequence that now the effects of the contractual arrangement on the differences in average input intensities can be identified more clearly. The direction of this influence, however, is not clear. Testing for each of the input equations whether all crop dummy coefficients are jointly equal to zero, this hypothesis is rejected only for the categories 'seed' ($\chi^2_{(4)} = 14.73$) and 'fertilizer' ($\chi^2_{(4)} = 10.37$) for the estimation using the predicted values, whereas it is rejected for the categories 'seed', 'farm yard manure', 'preharvest labour', and 'bullock labour' at different significance levels ($\chi^2_{(4)} = 50.90$, $\chi^2_{(4)} = 7.87$, $\chi^2_{(4)} = 18.87$, and $\chi^2_{(4)} = 12.08$, respectively) for the estimation using the actual values. These results indicate that failing to take into account the endogeneity of the crop choice leads to an overestimation (with no implication for the direction of the overestimation) of the influence of the crop types cultivated on owned and sharecropped plots on the difference in average input intensities (except for the input category 'fertilizer and pesticides'), and to an underestimation (no implication for the direction of the underestimation as well) of the influence of the contractual arrangements related with the tenancy.

Table 15 shows the results for the OLS estimation of the output difference equation, using both the actual and the predicted crop dummies. There are some changes in the signs and in the significance levels of the coefficients for the crop dummies, but the most important change is, that in the estimation which uses the predicted values the intercept is positive and significant at the 5% level, whereas in the estimation using the actual values the intercept is not significantly different from zero. Thus, for output, too, a positive difference between the average output intensities on owned and sharecropped land which cannot be ascribed to different irrigation or cropping pattern can be detected if one controls for the endogeneity of crop choice. That is, for output we find evidence for the Marshallian hypothesis. We also included all cost-share variables in the output difference estimation, but none of them was significant at any conventional significance level.

The joint hypothesis tests we have carried out so far test only whether a certain set of parameters is jointly significantly different from zero. Therefore, we could not say anything about the direction of the joint influence (if any) of the respective variables. But since for the variables connected with the contractual arrangement we are interested in the direction of their joint significance, we now proceed to test some inequality restrictions on sets of parameters. To test nonlinear cross-equations restrictions for a system of equations, Gallant and Jorgenson (1979) propose a test which is an analog of the likelihood ratio test, and which is based on the change in the least-squares criterion function. The test procedure is as follows: First estimate the unrestricted model (in our case by SUR), then estimate the restricted model (by SUR) using the same estimated variance-covariance matrix for the error terms as in the unrestricted model. Then the suggested test statistic is[18]

$$T^0 = n\left(\tilde{\tilde{S}} - \tilde{S}\right)$$

where $\tilde{\tilde{S}}$ is the value of the objective function of the restricted model, $\tilde{S}$ is the value of the objective function of the unrestricted model, an n is the number of observations used in the estimations. When the sample is in accord with the null hypothesis, T^0 will be near zero, and

[18] See Gallant and Jorgenson (1979, p.279).

when it is not, T^0 will be large. It can be shown, that T^0 is distributed asymptotically as a chi-square with m degrees of freedom when the null hypothesis is true, where m is the number of parameter restrictions.

We now test several joint hypotheses using this method, testing each hypothesis twice, once using the actual crop dummies and once using the predicted crop dummies in the estimation. Testing whether all intercepts are jointly smaller than or equal to zero, we find that the hypothesis cannot be rejected for the actual values (p-value 0.1093) and that it is rejected for the predicted values at the 10% level (p-value 0.0889). That is, only for the estimation using the predicted values we find evidence that the vector of mean differences in average input intensities on owned and sharecropped plots is positive in all its elements, even after controlling for other factors. That is, there is a generally lower input supply on the sharecropped plots than on the owned plots. The hypothesis that all supervision dummy coefficients are jointly bigger than or equal to zero cannot be rejected for the actual values (p-value 0.4989) and for the predicted values (p-value 0.3545). Therefore we cannot conclude that the supervision of input use by both the tenant and the landlord in general reduces the differences in average input intensities in either of the two models. The hypothesis that all cost-share coefficients are jointly smaller than or equal to zero cannot be rejected for the actual values (p-value 0.5405), but it is rejected at the 1% level for the predicted values (p-value 0.0044). Thus, in the model which takes into account the endogeneity of the crop choice there is strong evidence that a cost-share-output-share relation of the tenant which is bigger than one has in general a positive influence on the differences in average input intensities on owned and sharecropped plots. That is, if the cost-share of a tenant rises relative to his output-share, he will reduce the intensity of the respective input on his sharecropped plots by more than on his owned plots. In the model which assumes that the crop type cultivated on a particular plot is exogenously given, no influence of the cost-sharing rule on the differences in average input intensities can be identified.

Turning to the comparison of the results of the two models for the owner-fixed-renters, it is noticeable that for all variables and for all input categories there are some changes in the signs and in the significance of the coefficients.[19] In the estimation using the actual crop dummies, the hypothesis that the coefficients of all variables are jointly equal to zero for the respective input category could be rejected at the 1% level for all seven input categories. However, for the model which uses the predicted crop dummies, this hypothesis cannot be rejected for the category 'harvest labour' and can only be rejected at the 10% level for the category 'bullock labour'. That is, there is less explanatory power in the model which uses the predicted values. A reason for this could be that one loses variation in the explanatory variables if one uses the predicted values, so that the parameters cannot be estimated with much precision.

We find that the hypothesis that all intercept parameters are jointly equal to zero is rejected at the 1% level ($\chi^2_{(7)} = 28.05$ for the actual values and $\chi^2_{(7)} = 23.54$ for the predicted values) for both models. It is not, however, possible to establish a general direction of the mean difference in average input intensities in either of the two models: Using the test method of Gallant and Jorgenson, the hypothesis that all intercepts are jointly smaller than or equal to zero cannot be rejected for either the model using the actual values (p-value 0.1570) or the model using the predicted values (p-value 0.2871). This is not surprising, since some of the intercepts are positive and significant, and some of them are negative and significant. Thus, for the owner-fixed-renters there seems to be no evidence for a generally lower input supply on the leased-in

[19] For the category 'tractor hours' there is only a crop dummy for 'chillies', since in the two villages where tractors are used, only paddy and chillies are cultivated.

plots. The hypothesis that all relationship dummy coefficients are jointly equal to zero is rejected at the 5% level ($\chi^2_{(7)} = 17.67$) for the model using the actual values, but it cannot be rejected ($\chi^2_{(7)} = 5.97$) for the model which uses the predicted values. Again employing the Gallant-Jorgenson test method, the hypothesis that all relationship dummy coefficients are jointly bigger than or equal to zero is rejected at the 5% level (p-value 0.0426) for the model using the actual values, whereas for the model using the predicted values it cannot be rejected (p-value 0.5430). Thus, for the owner-fixed-renters there is exactly the opposite effect of the model which takes into account endogenous crop choice as in the case of owner-sharecroppers: The coefficients for the variable which captures an aspect of the tenancy contract are jointly significant in the model which takes the crop choice as exogenously given, and become jointly insignificant if the crop choice is considered endogenous.

Table 16 shows the results for the OLS estimation of the output difference equation. Worth mentioning is, that for both the actual and the predicted values estimation the intercepts are not significantly different from zero and that the coefficients for the relationship dummy are negative but not significant in both cases. Thus, there is no evidence that tenancy has any effect on the differences in average output intensities in the case of the owner-fixed-rent tenants.

4 Conclusion

Making predictions on the efficiency of risk sharing and on productive efficiency under different tenancy contracts often depends crucially on the assumption whether the actions taken by the tenant can be perfectly (costlessly) monitored by the landlord or not. If the landlord is able to stipulate the amounts of all inputs to be applied to the tenancy in the contract because he can control the tenant's actions at reasonable costs, then there is no reason why there should be different input intensities between owned plots, sharecropped plots, and plots cultivated under a fixed-rent contract. But if this control over the tenant's action is not possible for whatever reason, one would expect lower input intensities on sharecropped plots compared with owned plots and plots leased-in under a fixed-rent contract according to the predictions of the theory: Why should a rational farmer devote the same effort to the cultivation of a crop from the output of which he receives only one half as to the cultivation of a crop the surplus of which accrues wholly to him?

To assess empirically whether the Marshallian or the monitoring approach is valid, we used the method proposed by Shaban (1987), extending his analysis by introducing variables controlling for the crop types grown and for different aspects of the tenancy contract, such as the cost-sharing arrangement, the rules concerning the supervision of the production process, and the relationship between the landlord and the tenant. We studied both owner-sharecroppers and owner-fixed-rent tenants in order to clarify whether lower input intensities are the consequence of the sharecropping contract, or whether this is a phenomenon which can be ascribed to the effects of tenancy itself. Our main findings in the econometric model which takes the crop indicator variables as exogenously given are: (i) the hypothesis that all intercepts are jointly equal to zero is rejected for the owner-sharecroppers at the 5% level; but the hypothesis that these intercepts are jointly smaller than or equal to zero cannot be rejected, (ii) for the owner-fixed-renters, the hypothesis that all intercepts are jointly equal to zero can also be rejected at the 1% level, but no general direction for the differences can be established, (iii) for the owner-sharecroppers, the hypothesis that all cost share coefficients are jointly equal to zero is rejected at the 10% level and the hypothesis that all supervision dummy coefficients are jointly equal to zero cannot be rejected, (iv) for the owner-fixed-renters the hypothesis that all relationship dummy coefficients are jointly equal to zero can be rejected at the 5% level, but again no general direction of the influence can be established, (v) for the output difference estimation the intercept is significantly different from zero neither for the owner-sharecroppers nor for the owner-fixed-rent tenants.

We further estimated a model which takes into account the possibility that the crops grown on plots of different tenancy status are the outcome of an endogenous choice which is influenced amongst other things by the observed and unobserved characteristics of the tenant, and, for the crops cultivated under a tenancy, by the observed and unobserved characteristics of the landlord, too. In this case our main findings are: (i) the hypothesis that all intercepts are jointly equal to zero is rejected for the owner-sharecroppers at the 5% level; moreover, the hypothesis that these intercepts are jointly smaller than or equal to zero can be rejected at the 10% level, (ii) for the owner-fixed-renters, the hypothesis that all intercepts are jointly equal to zero can also be rejected at the 1% level, but no general direction for the differences can be established, (iii) for the owner-sharecroppers, the hypothesis that all cost share coefficients are jointly equal to zero can now be rejected at the 1% level and the hypothesis that all supervision dummy coefficients are jointly equal to zero can now be rejected at the 5% level; for the supervision dummies we cannot say in which direction the influence runs, whereas for the cost-share variables the hypothesis that they are jointly smaller than or equal to zero is rejected at the 1% level, (iv) for the owner-fixed-renters the hypothesis that all relationship dummy coefficients are jointly equal to zero cannot be rejected, (v) in the output difference estimation the intercept is significantly positive at the 5% level for the owner-sharecroppers, whereas it is not significant for the owner-fixed-rent tenants.

That is, in the model which uses the predicted values for the class of owner-sharecroppers the mean differences (the intercepts) between average input intensities on owned and sharecropped plots are positive for all inputs even after controlling for other factors, a finding which can be interpreted as evidence for the Marshallian approach. Controlling for the endogeneity of crop choice, we find also evidence for a positive difference between average output intensities on owned and sharecropped plots, again a finding which is in favor of the

Marshallian hypothesis. For the tenants cultivating owned plots and plots leased-in under a fixed-rent contract the mean differences are also jointly different from zero, but they have no uniform direction concerning their sign. Thus, we cannot conclude from either of the two models for this group of tenants that inputs are systematically undersupplied on their leased-in plots. Concerning the differences in average output intensities, we find in the case of the owner-fixed-rent tenants no evidence for a systematically lower output intensity on the leased-in plots. However, for the model which does not account for endogenous crop choice we find evidence that a kinship relation between the landlord and the tenant leads to higher input intensities on the leased-in plots of the owner-fixed-rent tenants, indicating that also fixed rent contracts may not be perfectly efficient. For both groups of tenants, different cropping patterns on owned and leased-in plots explain part of the differences between average input intensities on owned and leased-in plots. But for the owner-sharecroppers, in the model which takes into account the endogeneity of crop choice the influence of the cropping patterns on the input differences becomes less clear, whereas instead of this there is strong evidence that a higher cost-share relative to the output-share of the tenant has a stronger negative influence on the input intensities on the sharecropped-in plots than on the input intensities on his owned plots. This is in accordance with our theoretical predictions and has again the implication that the tenant's actions can be only imperfectly monitored. Otherwise, the characteristics of the contract would not have an influence on the difference in average input intensities.

Table 1: Total operational landholdings of households by tenancy status (in acres)

	mean	std.dev.	min	max	Number of households
pure owners	4.062973	6.57121 ($p<0.0001$)	0.20	40.61	110
owner/sharecropper owned plots	1.812308	1.65025 ($p<0.0001$)	0.20	7.86	37
owner/sharecropper shared plots	2.402051	2.97836 ($p<0.0001$)	0.11	14.82	37
owner/sharecropper total holdings	4.308462	3.97277 ($p<0.0001$)	0.53	19.03	37
owner/fixed-rent owned plots	2.665091	2.35017 ($p<0.0001$)	0.24	11.44	50
owner/fixed-rent leased plots	1.617818	1.70932 ($p<0.0001$)	0.18	10.01	50
owner/fixed-rent total holdings	4.468364	3.36182 ($p<0.0001$)	0.63	16.30	50

Tabel 2: Area irrigated under different tenancy contracts (in acres)

	irrigation status	average farm area	total area	paired t-test (equal irr. and unirr. farm area
all plots	irrigated unirrigated	0.49 1.40	97.73 281.84	-3.67 (p=0.0003)
pure owners	irrigated unirrigated	0.28 1.42	28.12 142.88	-2.77 (p=0.0067)
owner/sharecr. owned plots	irrigated unirrigated	0.07 0.65	2.77 25.17	-4.24 (p=0.0001)
owner/sharecr. shared plots	irrigated unirrigated	0.36 1.04	13.41 38.41	-1.75 (p=0.0889)
owner/sharecr. all plots	irrigated unirrigated	0.42 1.63	16.18 63.58	-3.26 (p=0.0024)
owner/fixed-r. owned plots	irrigated unirrigated	0.61 0.90	31.64 46.54	-0.88 (p=0.3823)
owner/fixed-r. leased plots	irrigated unirrigated	0.43 0.35	20.43 16.80	0.51 (p=0.6110)
owner/fixed-r. all plots	irrigated unirrigated	0.94 1.15	51.79 63.34	-0.53 (p=0.5994)

Table 3: Proportions of land grown under different crops

	pure owners	*owner-sharec. owned plots*	*owner-sharec. sharec. plots*	*owner-fix owned plots*	*owner-fix leased plots*
paddy	0.20	0.10	0.26	0.50	0.49
cereals	0.24	0.32	0.25	0.15	0.17
grams	0.06	0.11	0.11	0.03	0.05
groundnut	0.21	0.25	0.12	0.10	0.16
castor seed	0.09	0.14	0.10	0.07	0.04
cotton	0.11	0.05	0.16	0.09	0.04
chillies	0.02	0.03	0.00	0.04	0.01
sugarcane	0.02	0.00	0.00	0.002	0.004
others	0.05	0.003	0.00	0.007	0.03
total area	431.26	80.80	104.37	171.84	100.90

Total area is measured in acres. Total areas differ from total areas in table 2a, since in this table we use observations from both seasons, whereas in table 2a each plot appears only once in the computations.

Table 4: Mean input intensities for different crops (all plots in crop production schedule)

	preharvest labour	harvest labour	bullock-pair days	seedlings	farm yard manure	fertilizer/ pesticides	number of plots
paddy	149.76 (77.10)	56.88 (24.90)	38.51 (51.82)	196.42 (501.12)	203.26 (486.27)	534.65 (758.49)	235
cereals	30.74 (77.10)	41.33 (24.90)	16.86 (14.73)	48.65 (147.17)	45.70 (119.55)	31.46 (102.34)	155
grams	3.30 (6.15)	56.75 (69.19)	2.80 (5.29)	117.88 (106.34)	8.31 (33.88)	20.13 (74.68)	112
groundnut	57.85 (34.10)	37.71 (28.49)	15.64 (7.77)	671.77 (510.74)	94.89 (159.00)	236.91 (372.86)	116
castor seed	17.11 (5.61)	27.49 (21.56)	15.76 (5.27)	36.56 (14.50)	28.72 (49.57)	7.08 (21.23)	52
cotton	32.43 (32.76)	13.67 (6.70)	11.06 (3.12)	28.78 (5.19)	19.05 (40.26)	64.85 (111.77)	20
chilies	254.78 (196.45)	98.87 (65.66)	34.06 (39.15)	187.61 (170.85)	582.26 (766.60)	532.98 (474.67)	36
sugarcane	190.44 (99.82)	90.41 (87.63)	21.86 (16.45)	1330.08 (1870.28)	186.95 (359.88)	638.17 (442.00)	22

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs are in rupees per acre. Standard deviations are in parentheses.

Table 5: Mean differences in average input and output intensities

	owner-sharecropper		*owner-fixed-rent*	
	mean differences in average input intensities (std. error)	t-value	mean differences in average input intensities (std. error)	t-value (p-value)
seedlings	33.65	1.14	-86.25*	-1.83
	(29.59)		(47.02)	
fertilizer/ pesticides	3.64	0.21	-107.72***	-3.17
	(17.72)		(33.97)	
farm yard manure	8.99	0.43	11.34	1.36
	(21.10)		(8.31)	
preharvest labour	-10.01	-1.13	-8.89	-1.56
	(8.83)		(5.69)	
harvesting labour	7.06	1.67	-12.76***	-2.90
	(4.24)		(4.40)	
bullock pair days	-2.94	-0.83	-7.55**	-2.28
	(3.53)		(3.31)	
tractor hours	-	-	-52.98***	-6.37
			(8.31)	
output	-301.28	-1.04	-857.80*	-1.78
	(289.65)		(481.52)	
χ^2-value		21.23		67.13

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs and output are in rupees per acre. ***, **, * denotes significance at the 1%, 5%, 10% level, respectively.

Table 6: Differences on owned and sharecropped land of owner-sharecroppers (n=43)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*bullock pair days*	*output*
intercept	144.12**	-77.47	115.44*	12.50	11.98	9.73	182.33
	(62.23)	(47.25)	(59.87)	(13.25)	(12.91)	(8.02)	(147.61)
irrigation	163.03***	157.46***	80.82**	67.89***	12.51	19.16***	3062.39***
	(40.92)	(28.91)	(35.30)	(10.63)	(8.21)	(5.60)	(269.35)
grams	-470.57	-364.01	-	-244.13*	-167.24	-125.46	-
	(572.60)	(403.40)		(128.10)	(107.50)	(81.13)	
groundnut	410.98***	-7.02	-122.98**	-52.37***	-14.13	-16.75**	-
	(56.79)	(40.70)	(51.64)	(14.55)	(11.23)	(7.38)	
castor seed	-	-	-76.64**	-	-	15.39**	-
			(37.00)			(5.09)	
cost share	-100.61**	88.04**	-55.79	-2.02	-1.52	-3.76	-
	(48.39)	(37.12)	(46.60)	(9.57)	(9.55)	(4.39)	
super-vision	-46.75	-109.09*	-41.95	-21.67	29.15*	-14.52	-
	(65.77)	(57.47)	(79.99)	(19.59)	(17.02)	(8.78)	
decision cropping pattern	-	-	-	-	-	-	-867.40
							(617.07)
adjusted R-square	0.62	0.48	0.33	0.67	0.22	0.43	0.78
χ^2-value	80.33	47.45	29.05	100.53	20.79	47.26	-
F-value	-	-	-	-	-	-	68.17

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs and output are in rupees per acre. Standard errors are in parentheses. ***, **, * denotes significance at the 1%, 5%, 10% level, respectively.

Table 7: Differences on owned and leased-in land of owner-fixed-rent tenants, (n=75)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*tractor hours*	*bullock pair days*	*output*
intercept	94.09 (57.23)	17.80 (39.58)	36.38*** (12.06)	6.97 (7.42)	-2.62 (5.81)	-30.09** (13.25)	-3.12 (3.12)	-25.13 (256.53)
irrigation	65.79 (68.17)	254.26*** (59.44)	51.28*** (14.07)	31.33** (11.88)	-3.45 (7.81)	42.96** (17.04)	3.18 (3.64)	4356.95*** (818.95)
cereals	-177.71 (124.10)	-180.55** (83.00)	-	-31.67* (17.93)	-	-	-	-
grams	-	-	-	-	-	-	-187.79*** (28.84)	-
groundnut	400.43** (178.00)	-	-60.64* (31.73)	-41.60* (22.49)	-105.99*** (15.47)	-	-35.56*** (8.20)	-
cotton	-	-317.35** (142.00)	-	-39.94 (27.44)	-46.24*** (15.57)	-	-	-
chillis	-	-	-	-	-	-	-35.84** (14.12)	-
sugarcane	1857.07*** (285.00)	-	-	-	-	-	-	19061.00*** (1930.84)
relation-ship	-214.31** (88.39)	-66.20 (63.25)	-23.43 (18.56)	-20.22* (11.83)	-17.72* (9.08)	-19.02 (18.02)	-7.94 (4.83)	-
village	-166.06** (76.58)	-59.46 (56.08)	-8.04 (15.93)	4.52 (10.77)	-0.42 (7.97)	-	7.65* (4.12)	-
adjusted R-square	0.37	0.40	0.17	0.22	0.37	0.21	0.47	0.75
χ^2 -value	68.35	80.01	21.07	36.51	67.64	37.58	117.40	-
F-value	-	-	-	-	-	-	-	91.14

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs and output are in rupees per acre, and tractor hours are in hours per acre. Standard errors are in parentheses, p-values are in brackets. ***, **, * denotes significance at the 1%, 5%, 10% level, respectively.

Table 10: Multinomial logit estimates for the crop choice equations

	owner-sharecropper	*owner-fixed-rent*
irrigation.paddy	34.20 (13.60)**	13.81 (2.59)***
irrigation.cereals	-1.17 (0.80)	-16.17 (1331)
irrigation.sugarcane	-	24.71 (7.86)***
irrigation.others	30.68 (13.83)**	0.78 (0.55)
famlabmt.paddy	-1.44 (0.48)***	0.16 (0.36)
famlabmt.groundnut	-0.52 (0.23)**	-0.16 (0.20)
famlabft.chillies	-	-0.56 (0.35)
famlabml.paddy	-3.34 (2.04)	-4.67 (2.02)**
famsizt.paddy	-0.36 (0.24)	-0.59 (0.13)***
famsizt.cereals	0.04 (0.06)	-0.002 (0.08)
famsizl.paddy	1.08 (0.59)*	1.01 (0.57)*
draughtt.paddy	0.80 (0.42)*	1.03 (0.44)**
draughtt.cotton	0.40 (0.29)	0.27 (0.17)
machint.paddy	2.80 (1.63)*	-3.09 (0.62)***
machint.grams	-1.25 (0.78)	-1.37 (0.46)***
wellt.cotton	-15.89 (1217)	-2.88 (0.82)***
landownt.paddy	0.12 (0.29)	-0.64 (0.20)***
landownt.cereals	0.11 (0.11)	0.06 (0.07)
aget.groundnut	0.002 (0.02)	-0.02 (0.02)
aget.chillies	-	0.05 (0.03)*
aget.sugarcane	-	-0.12 (0.08)
assett.paddy	2.34 (1.17)**	1.97 (0.61)***
assett.cereals	-0.66 (0.92)	-1.36 (0.73)*
assett.grams	1.64 (0.55)***	0.95 (0.51)*
assett.chillies	-	0.48 (0.54)
assetl.paddy	0.86 (0.96)	0.63 (0.65)
assetl.cereals	-0.02 (0.48)	0.61 (0.39)
assetl.grams	-0.91 (0.55)*	0.59 (0.37)
labourcosts	-0.41 (0.18)**	-0.03 (0.02)*
othercosts	0.03 (0.01)**	-0.009 (0.006)
number of observations	282	431
log likelihood	-336.11	-329.67

Standard errors are in parentheses, p-values are in brackets.

Table 10a: Residence status of landlords

	resident landlord	non-resident landlord	total
sharecroppers	53 72.60 33.97	20 27.40 33.33	73 33.80
fixed-rent tenants	103 72.03 66.03	40 27.97 66.67	143 66.20
total	60 27.78	156 72.22	216 100.00

The order of the cell entries form top to bottom is: frequency, row percent, and column percent. The overall chisquare is $\chi^2_{(1)} = 0.008$.

List of variables in the multinomial logit model

Variable	*Description*
irrigation.	dummy variable (=1 if the plot is irrigated, =0 otherwise)
famlabmt.	number of adult male workers in the tenant's family
famlabft.	number of adult female workers in the tenant's family
famlabml.	number of adult male workers in the landlord's family
famsizt.	number of individuals in the tenant's family
famsizl.	number of individuals in the landlord's family
draughtt.	number of the tenant's draught animals
machint.	number of agricultural machines owned by the tenant
wellt.	number of wells owned by the tenant
landownt.	total land owned by the tenant (in acres)
aget.	age of the tenant
assett.	total asset value of the tenant (in 100,000 rupees)
assetl.	total asset value of the landlord (in 100,000 rupees)
labourcosts	average amount of working hours used in the cultivation of a particular crop (in hours)
othercosts	total average costs of other inputs (fertilizer, pesticides, farm yard manure) used in the cultivation of a particular crop (in rupees)

Table 11: Differences on owned and sharecropped land of owner-sharecroppers, actual crop dummies (n=43)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*bullock pair days*
intercept	141.86**	-77.71	132.93**	12.31	12.94	10.35
	(65.44)	(51.30)	(63.30)	(13.50)	(13.41)	(8.04)
irrigation	165.41***	156.15***	108.23**	66.35***	10.26	10.69
	(54.82)	(39.03)	(50.54)	(14.43)	(11.06)	(7.63)
cereals	-13.03	-10.46	70.95	1.87	-1.90	-14.63*
	(51.71)	(36.72)	(47.76)	(13.95)	(10.55)	(7.47)
grams	-23.95	-30.51	4.32	-37.78	-22.69	-21.17
	(107.90)	(71.90)	(93.81)	(27.82)	(20.94)	(15.66)
groundnut	390.17***	-24.50	-87.28	-63.38***	-22.01*	-28.56***
	(60.62)	(42.84)	(55.46)	(15.76)	(11.99)	(8.40)
cotton	9.63	13.27	-63.44	11.77	-17.56	-8.39
	(150.10)	(107.00)	(138.90)	(39.76)	(29.97)	(21.36)
super-vision	-45.45	-111.32*	-69.35	-25.32	25.71	-12.60
	(72.38)	(60.09)	(79.03)	(20.12)	(17.46)	(9.68)
cost share	-97.86*	89.22**	-70.20	-0.86	-1.82	-3.92
	(51.15)	(40.73)	(49.98)	(9.80)	(9.97)	(4.37)
adjusted R-square	0.60	0.44	0.33	0.65	0.18	0.37
χ^2 -value	74.26	43.19	28.47	95.20	18.53	35.52

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs are in rupees per acre. Standard errors are in parentheses.

Table 12: Differences on owned and sharecropped land of owner-sharecroppers, predicted crop dummies (n=43)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*bullock pair days*
intercept	-117.24	-98.41**	220.28***	18.12	21.31	17.06*
	(94.59)	(48.05)	(75.51)	(16.49)	(14.53)	(9.87)
irrigation	122.63	146.07***	171.31**	83.33***	19.22	13.55
	(79.73)	(41.84)	(70.08)	(19.57)	(13.29)	(10.57)
cereals	576.56	234.14	-129.92	76.23	-74.78	-24.24
	(380.10)	(199.80)	(332.40)	(90.97)	(63.68)	(47.46)
grams	-484.77**	-279.89**	45.57	-9.88	19.68	-35.92
	(216.80)	(112.80)	(190.00)	(54.00)	(36.92)	(29.51)
groundnut	-102.45	-232.72	31.35	-169.54*	11.65	-17.23
	(352.60)	(189.40)	(315.40)	(85.37)	(60.55)	(44.11)
cotton	-1866.50	326.08	2094.80*	287.44	288.12	156.13
	(1308.50)	(689.00)	(1157.10)	(327.30)	(224.60)	(176.50)
super-vision	-83.46	-96.02	-92.99	-7.74	27.26	-13.42
	(88.85)	(58.06)	(96.96)	(22.44)	(18.49)	(10.08)
cost share	147.62**	121.31***	-126.95**	-7.78	-8.31	-6.57
	(67.31)	(34.06)	(52.87)	(10.55)	(9.86)	(5.27)
adjusted R-square	0.37	0.56	0.30	0.56	0.17	0.22
χ^2 -value	31.64	65.29	24.45	68.59	17.13	23.11

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs are in rupees per acre. Standard errors are in parentheses.

Table 13: Differences on owned and leased-in land of owner-fixed-rent tenants, actual crop dummies (n=75)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*tractor hours*	*bullock pair days*
intercept	98.66*	18.74	36.54***	6.61	-2.97	-27.55**	-5.16
	(58.81)	(42.14)	(12.44)	(7.78)	(6.02)	(13.36)	(3.58)
irrigation	-57.56	293.98***	17.49	27.71*	7.93	49.59***	0.78
	(102.00)	(75.41)	(21.23)	(14.13)	(10.62)	(17.91)	(6.10)
cereals	-453.76**	-72.27	-85.65*	-42.26	39.30*	-	12.31
	(211.30)	(152.50)	(44.53)	(28.23)	(21.70)		(12.81)
grams	549.63	12.80	51.93	-38.40	-0.13	-	-144.69***
	(849.80)	(607.00)	(180.00)	(111.80)	(86.77)		(51.78)
groundnut	151.51	31.67	-129.50***	-50.56*	-82.19***	-	-28.63**
	(227.70)	(163.90)	(48.06)	(30.31)	(23.35)		(13.82)
cotton	-343.40	-236.61	-91.72*	-52.07	-23.69	-	-10.49
	(243.90)	(177.50)	(51.21)	(32.99)	(25.17)		(14.72)
chillis	-58.41	255.17	-59.77	10.23	34.59	91.99	-64.54***
	(363.20)	(259.90)	(76.84)	(47.93)	(37.13)	(238.80)	(22.10)
sugarcane	1812.59***	-105.96	-22.08	-10.30	-11.60	-	-24.23
	(336.00)	(240.00)	(71.15)	(44.20)	(34.30)		(20.47)
others	-214.40	155.63	-85.96**	-14.24	33.21	-	-2.54
	(202.10)	(145.20)	(42.70)	(26.81)	(20.70)		(12.28)
relation-ship	-212.68**	-73.05	-21.79	-20.76*	-18.72**	-22.08	-3.56
	(90.03)	(65.88)	(18.85)	(12.28)	(9.32)	(18.19)	(5.41)
village	-204.57**	-46.49	-18.20	3.97	3.51	-	7.25
	(82.15)	(60.40)	(17.16)	(11.29)	(8.53)		(4.93)
adjusted R-square	0.35	0.36	0.16	0.19	0.34	0.20	0.34
χ^2-value	60.81	77.43	26.71	36.04	67.45	38.78	52.01

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs are in rupees per acre, and tractor hours are in hours per acre. Standard errors are in parentheses.

Table 14: Differences on owned and leased-in land of owner-fixed-rent tenants, predicted crop dummies (n=75)

Variable	*seed*	*fertilizer and pesticides*	*farm yard manure*	*preharv. labour*	*harvest labour*	*tractor hours*	*bullock pair days*
intercept	-11.15	22.82	37.24***	3.17	-11.61	-34.46**	-3.43
	(63.75)	(45.05)	(13.26)	(7.69)	(7.94)	(13.68)	(4.44)
irrigation	49.44	319.84***	44.73**	25.36**	2.77	44.61**	-0.34
	(99.14)	(72.27)	(20.39)	(12.67)	(12.43)	(18.01)	(6.83)
cereals	510.21	-364.92	27.84	-119.74*	-13.58	-	-73.41**
	(515.90)	(365.50)	(107.20)	(62.51)	(64.26)		(35.91)
grams	-2116.09**	676.69	-154.89	83.58	5.49	-	184.35***
	(912.20)	(645.70)	(189.70)	(110.30)	(113.60)		(63.52)
groundnut	532.30	3851.44*	723.13	-140.14	-467.02	-	-54.57
	(2970.3)	(2095.3)	(618.30)	(356.90)	(369.60)		(207.10)
cotton	971.08	-693.16	-459.04*	-110.48	115.41	-	-108.53
	(1231.9)	(869.90)	(256.30)	(148.30)	(153.30)		(85.86)
chillis	3714.11**	-7.10	204.09	-173.17	19.05	-217.53	-33.42
	(1527.3)	(1108.6)	(314.60)	(193.70)	(191.30)	(265.00)	(105.30)
sugarcane	2902.78**	1604.02	311.02	-94.91	-23.51	-	-110.50
	(1442.1)	(1017.3)	(300.20)	(173.30)	(179.40)		(100.50)
others	-4400.59*	-3235.99*	-406.20	178.68	223.02	-	66.62
	(2506.1)	(1780.6)	(520.30)	(305.30)	(312.40)		(174.30)
relation-ship	-93.41 (94.88)	-76.81 (68.49)	-14.82 (19.59)	-15.73 (11.91)	-11.73 (11.87)	-13.34 (19.01)	-7.74 (6.56)
village	-128.81	-25.84	-16.43	4.47	8.13	-	9.92*
	(86.40)	(62.72)	(17.80)	(10.96)	(10.82)		(5.96)
adjusted R-square	0.20	0.32	0.17	0.22	-0.05	0.21	0.06
χ^2 -value	36.98	68.53	26.47	43.20	15.29	38.86	18.28

Preharvest labour, harvest labour, and bullock-pair days are measured in days per acre, the other inputs are in rupees per acre, and tractor hours are in hours per acre. Standard errors are in parentheses.

Table 15: Output differences (owner-sharecroppers)

	output (actual values)	*output (predicted values)*
intercept	58.86 (149.12)	499.12 (190.22)**
irrigation	1531.34 (864.65)*	-7840.22 (2649.82)***
cereals	-2396.46 (1181.33)*	-1040.51 (4439.96)
grams	-3687.41 (1327.07)***	-13856.00 (3310.88)***
groundnut	-125.72 (836.61)	-12661.00 (6575.38)*
cotton	-2518.49 (1489.44)*	-234.44 (12528.00)
castor seed	-2079.57 (1227.99)*	-27169.00 (20533.00)
others	-2937.08 (1476.26)*	49896.00 (13611.00)***
decision cropping pattern	-534.50 (564.59)	-789.21 (579.43)
adjusted R-square	0.83	0.83
F-value	25.90	25.89

Output is measured in rupees per acre. Standard errors are in parentheses.

Table 16: Output differences (owner-fixed-rent tenants)

	output (actual values)	*output (predicted values)*
intercept	264.70 (345.10)	-480.44 (610.12)
irrigation	5656.17 (1920.38)***	9530.50 (10247.00)
cereals	2437.02 (1958.85)	4217.55 (16317.00)
grams	784.90 (5261.73)	-12290.00 (12958)
groundnut	3969.36 (1804.31)**	57643.00 (50998.00)
cotton	-67.19 (2049.55)	23832.00 (12758.00)*
chillies	3096.61 (1891.23)	75341.00 (29732.00)**
sugarcane	21517.00 (1889.76)***	18302.00 (21179.00)
others	2503.94 (1237.83)**	-115717.00 (42310.00)***
relationship	-844.83 (505.26)*	-405.00 (853.29)
village	-101.69 (446.43)	391.71 (732.96)
adjusted R-square	0.82	0.51
F-value	28.79	7.34

Output is measured in rupees per acre. Standard errors are in parentheses.

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