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MORAL HAZARD AND MARSHALLIAN INEFFICIENCY : EVIDENCE FROM TUNISIA

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RÉSUMÉ

En présence de risque moral, la théorie de l'agence prédit que l'utilisation des intrants par hectare sera différente sur les terres exploitées en métayage par rapport aux terres cultivées par des propriétaires-exploitants. Dans cette étude, nous testons pour la présence de cette "inefficacité marshallienne" du métayage en utilisant des données provenant du village tunisien d'El Oulja. Nous considérons quatre questions qui ont été ignorées dans les travaux empiriques sur le métayage : (i) le partage des coûts entre propriétaire et métayer, (ii) les intrants en gestion agricole fournis par le propriétaire, (iii) les activités de supervision des propriétaires et (iv) l'interaction répétée entre propriétaires et tenanciers. Nous appliquons une méthode d'estimation en panel "trimmed LAD" proposée par Honoré (1992). Nos résultats montrent que les termes du contrat ont un effet significatif sur l'utilisation des intrants et que le risque moral est donc présent. Par contre, nos résultats rejettent l'interprétation traditionnelle de l'inefficacité marshallienne: à El Oulja, l'intensité de l'utilisation des intrants n'est pas moindre sur les parcelles de terre exploitées en métayage.

Mots clés : risque moral, inefficacité marshallienne, métayage, contrats agricoles, intrants non commercialisés

ABSTRACT

In the presence of moral hazard, received agency theory predicts the "Marshallian inefficiency" of agricultural tenancy contracts, meaning that inputs per hectare on sharecropped land will differ from that on owned land. In this paper, we test for the presence of Marshallian inefficiency using a unique data set collected in the Tunisian village of El Oulja in 1993. We focus on four issues which have heretofore been neglected in empirical studies of sharecropping : (i) the cost-sharing elements of tenancy contracts, (ii) managerial inputs provided by landlords, (iii) supervisory activities by landlords and (iv) repeated interaction between tenants and landlords. We apply fixed-effect panel estimation techniques and control for censoring in the left-hand side variable using a trimmed LAD estimator proposed by Honoré (1992). Our results support the view that the terms of tenancy contracts significantly affect input intensity and thus that moral hazard is relevant. However, our findings strongly reject the traditional interpretation of Marshallian inefficiency which holds that input intensity will be lower on sharecropped land.

Key words : moral hazard, Marshallian inefficiency, sharecropping, agricultural tenancy, unmarketed inputs

> ". . . when the cultivator has to give to his landlord half of the returns to each dose of capital and labour that he applies to the land, it will not be to his interest to apply any doses the total return to which is less than twice enough to reward him. If, then, he is free to cultivate as he chooses, he will cultivate far less intensively than on the English [fixed rental] plan; he will apply only so much capital and labour as will give him returns more than twice enough to repay himself: so that his landlord will get a smaller share even of those returns than he would have on the plan of a fixed payment."
>
> (Alfred Marshall, *Principles of Economics* (Eighth edition, 1920), pp. 535-6)

1. INTRODUCTION

Sharecropping is often cited as the prototypical example of moral hazard.[1] Received agency theory predicts that, in the presence of moral hazard, inputs and output per hectare on sharecropped land will differ from those on owned land, *ceteris paribus*. The discrepancy arises because the sharecropping tenant does not receive the full benefit of his inputs and so will supply too little of them. This discrepancy has become known as the "Marshallian inefficiency" result.[2] In contrast to the so-called Marshallian view, the perfect monitoring approach, usually referred to as the Cheungian point of view (Cheung, 1968, 1969a, 1969b), posits that the landlord who owns the land being sharecropped has access to a costless monitoring technology which allows her to eliminate the moral hazard problem and force the peasant into achieving the first-best optimum which is achieved by an owner-operator. A central issue in Development Economics is to determine whether the Marshallian or the Cheungian view is the more appropriate depiction of reality.[3] This paper uses a unique dataset to examine this issue.

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[1] See, e.g., Grossman and Hart (1983), p. 7.

[2] Excellent surveys are provided by Newberry (1975), Binswanger and Rosenzweig (1984), Quibria and Rashid (1984), and Otsuka and Hayami (1988).

[3] The empirical literature on the topic of Marshallian efficiency *per se* is vast. Representative studies of the effect of tenancy on output or input intensity include Heady (1955), Ransom and Sutch (1973), Huang (1975), Berry and Cline (1979), Bliss and Stern (1982), Nabi (1986) and Sen (1981). Also see the copious references cited in Otsuka and Hayami (1988), note 47.

We focus on four classes of variables: (i) managerial inputs provided by the landlord; (ii) cost-sharing elements of the contracts; (iii) supervisory activities by the landlord; and (iv) repeated interaction between the landlord and the peasant. We examine whether these variables influence input and output intensity. Our main findings are: (i) managerial inputs have significant effects on some inputs; (ii) the cost-sharing elements of the contract have significant effects on all inputs except for male family labor and chemical fertilizer; (iii) supervisory activity by landlords significantly influences irrigation, chemical fertilizer use, and output, while repeated interaction significantly affects plowing, the use of manure, and output; (iv) supervision and repeated interaction jointly have significant effects on output and all inputs except for male family labor; (v) input intensities are higher on sharecropped land than on owned land for six out of ten inputs; and (vi) the quantitative importance of the terms of the contract in explaining inputs and output per hectare is small compared with the importance of plot characteristics.

Taken together, these findings reject the Cheungian view. However, the third and the fourth finding suggest that the landlord's monitoring does matter and is both costly and partial. Thus, reality is likely to be a mixture of both the Cheungian and the Marshallian views. The first finding supports the two-sided moral hazard model of Eswaran and Kotwal (1985). The fifth finding rejects the traditional interpretation of Marshallian inefficiency that input and output intensity are lower on sharecropped land than on owned land. The sixth finding suggests that the moral hazard problem, though it exists, is not likely to be important. This leads us to conclude that the role of sharecropping contracts in mitigating the moral hazard problem is relatively limited, and that they may be chosen for other reasons (e.g. risk-sharing or transactions-costs).

The empirical literature on sharecropping is large. Representative studies include Bell (1977) and Shaban (1987). There are three problems with this literature. First, it neglects all four classes of variables mentioned above. Thus, its results are subject to omitted variables bias. Second, previous tests of Marshallian efficiency, which were based on the traditional interpretation of Marshallian inefficiency, are inappropriate because Marshallian inefficiency does not necessarily imply lower input and output intensity on sharecropped land versus owned land. This follows because: (i) managerial inputs on sharecropped land may be provided by the landlord while those on owned land are always provided by the peasant; (ii) the landlord's monitoring may be partial on sharecropped plots while on owned land no monitoring is needed; and (iii) the ratios of the cost shares to the output share accruing to the peasant on sharecropped land may not be equal to one, while they are equal to one by definition on owned land; thus, simply comparing average input and output intensity, without taking potentially differing managerial inputs, differences in monitoring technologies, and the terms of the contract into account, may lead one to erroneously reject Marshallian efficiency. Third, the existing literature ignores the potential censoring of input variables. When working with input data at high levels of disaggregation, it is very likely that some inputs are not used. When this happens, the corresponding input variables will be recorded as zero and hence input data are subject to a censoring problem. If this censoring problem is not addressed statistically, then the parameter estimates of equations such as those of Bell (1977) and Shaban (1987) may be biased. As will become apparent below, our data on inputs display a severe censoring problem and hence appropriate statistical techniques must be used (see section 3 for further discussions on this topic).

In this paper, we extend the approach suggested by Bell (1987) and Shaban (1987), but our rich data set allows us to control for the key variables that have been omitted in previous work. Our basic approach involves fixed effect panel estimation of input and output intensities. In contrast to previous authors, we address the Marshallian inefficiency issue by testing the departure from the first best optimum. We also address the censoring problem by applying the symmetrically trimmed LAD estimation technique suggested by Honoré (1992).

The paper is organized as follows. Section 2 describes the data. Section 3 describes our empirical methodology. Section 4 presents the results. Section 5 concludes the paper.

2. DATA

The data used in the estimations come from a survey carried out by the authors in the Tunisian village of El Oulja during the autumn of 1993, as well as from a survey carried out by Laffont and Matoussi in 1986 (see Laffont and Matoussi (1995)). Detailed information regarding inputs, output, terms of the contract, and land characteristics was collected for each plot of land. Moreover, particular attention was paid to the four classes of variables described above, namely: management decisions, cost-sharing elements of contracts, supervisory activities by landlords, and repeated interaction. In what follows, we describe the variables that were used in our estimations and provide summary statistics for these variables.[4]

In our dataset, 101 households cultivate more than one plot. This accounts for 589 observations (plots of land), of which 41.4% were cultivated under tenancy contracts; 68 households cultivated at least one plot under tenancy arrangements, while 49 households were of mixed tenure status meaning that they were either owners/sharecroppers, owners/fixed-rent tenants, or owners/sharecroppers/fixed-rent tenants.[5]

The first set of variables used in the estimations are those pertaining to management decisions. Agricultural management plays a key role in the two-sided moral hazard, or "unmarketed inputs" model of sharecropping

[4] Readers are referred to Arcand and Ethier (1995a,b) for a brief portrait of the village. To the best of our knowledge, there is one other paper dealing with El Oulja. Matoussi and Nugent (1989) argue in favor of a transactions cost-based explanation for the shift towards greater reliance on sharecropping contracts in El Oulja during the 1970s which draws on the intuition provided by Eswaran and Kotwal (1985). There appears to have been a shift back away from sharecropping contracts in the 1980s: according to Matoussi and Nugent (1989), 12.1% of households were involved in at least one sharecropping contract before 1970, in contrast to 73.8% in their 1981 and 1985 surveys. In our 1993 survey, 9.6% of households were involved in at least one sharecropping contract. In 1986, that number was 28.6%. Matoussi and Nugent also argue that one of the reasons for the shift towards sharecropping in 1970s was the reduction in available supervisory labor caused by the emigration of "secondary workers" from El Oulja. They also cite the rise in agricultural wage rates, the increase in the percentage of plots which are irrigated, and (because of greater irrigation and readier access to markets) the rising importance of supervision and agricultural management.

[5] These households are potentially useful for testing why peasants choose one contractual form over others, a project that we are currently pursuing.

developed by Eswaran and Kotwal (1985).[6] In El Oulja, these decisions include: (1) the choice of the crop; (2) the timing and type of plowing; (3) the type, timing and quantity of irrigation; (4) the marketing of the output; (5) the party in the tenancy contract who has final say regarding management of agricultural production; (6) type and quantity of seed; (7) type of transportation; (8) type and quantity of fertilizer; (9) type and quantity of insecticide; (10) the amount of family labor; (11) the amount of hired labor; and (12) the timing of the harvest. These variables are dichotomous: a value of zero indicates that the tenant takes the management decision in question whereas a value of one indicates that it is the landlord who does. Since they are always responsible for management decisions, these variables always take on a value of zero for owner-operators. It is clear that these variables involve three types of decisionmaking: (i) the marketing of the product; (ii) the management of production; and (iii) the enforcement of the landlord's desired level of factor inputs. Thus, these decisions are not confined to agricultural management. Because landlord decisionmaking may also play the role of monitoring, the effects of these variables on inputs and on output cannot be unambiguously signed, and will depend on how landlords intervene in determining input intensities.

In our dataset, landlords take at least one agricultural management decision on 16.8% of the plots, all of which are cultivated under sharecropping contracts, while peasants make the management decisions on 34.4% of sharecropped plots.[7] These data exhibit perfect multicollinearity, in the sense that each decision variable can be expressed as a linear combination of the first five. Thus, only the first five variables were used in the actual estimation. The coefficients on these five variables must then be interpreted as the effects on inputs and output of these as well as the excluded decision variables.

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[6] On models of sharecropping which stress the importance of managerial or other unmarketed inputs, also see Reid (1976), Bliss and Stern (1982), Pant (1983).

[7] The first fact is consistent with, while the latter runs contrary to, the arguments put forward by Eswaran and Kotwal (1985), who show that landlords will provide the agricultural management inputs when sharecropping is the optimal contractual form.

The second set of variables used in our empirical work are those regarding cost-sharing arrangements.[8] In El Oulja, cost-sharing arrangements are quite common and are heterogeneous across tenancy contracts. For sharecropping and fixed rental contracts, cost sharing is particularly prevalent in the case of seeds (32.9% of contracts include cost sharing), transportation (31.4%), and irrigation (31.2%). It is least likely in the case of family and hired labor costs (9.7% and 13.0% of tenancy contracts include cost-sharing arrangements for these inputs, respectively). Almost all cost-sharing occurs within the context of sharecropping contracts, although there are a few examples of cost-sharing elements in fixed rental contracts. Table 1 presents the ratio of the cost share borne by the tenant to his output share for sharecropping contracts, by factor input. As can be seen in the table, there are many contracts, particularly when one considers family and hired labor inputs, where the ratio reaches a value of two, as well as a significant proportion where the ratio is well below one.[9]

If the peasant is free to choose inputs, then the *ratio* of the cost share to output share accruing to the tenant for a given input should have a negative effect on output, a negative effect on the corresponding input, and a positive (negative) effects on other inputs if these inputs are substitutes (complements). However, because the landlord may enforce her desired input level, the peasant may not be free to choose the level of inputs.[10]

The third set of variables we will consider involves information pertaining to the supervisory activities of landlords on plots under tenancy

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[8] Cost-sharing contracts have been modelled using capital constraints (Jaynes (1982, 1984), Bardhan (1984, ch. 7)), transactions-costs (Allen and Lueck (1993)), and asymmetric information (Braverman and Stiglitz (1986), Bardhan and Singh (1987)).

[9] Note that 86.5% of sharecropping contracts specify an output share of 0.5. There is therefore very little heterogeneity across contracts in terms of output share. Almost all of the heterogeneity in the cost to output share thus stems from differences in cost shares.

[10] The landlord's desired level of a given input can be higher or lower than the peasant's. To see this, suppose that the share of output accruing to the tenant is equal to 0.5, that the share of costs accruing to the peasant that are associated with input 1 equals 0.25, while the peasant bears all of the costs associated with input 2. Then the ratios of cost-share to output share accruing to the peasant are equal to 0.5 and 2 for inputs 1 and 2, respectively, while for the landlord, the corresponding ratios are 1.5 and 0. Thus, the peasant's desired level of input 1 will be higher than the landlord's, whereas the opposite will be true for input 2. For more details, see the formalisation presented in section 3.

contracts.[11] This information is relatively limited. What we know is the frequency of visits by the landlord to the peasant. We know neither what activities were carried out by the landlords during each visit, nor what triggered the visit. While visits by the landlord may be associated with monitoring of the peasant's activities, they may also be linked to management decisions on the part of the landlord, as well as with unforeseen difficulties encountered by the peasant during the growing season. This implies that the direction of the effect of this variable on output and inputs is not clear. For instance, if these visits involve enforcing the landlord's input quantities, then the effects will be positive (negative) if the peasant's desired level of inputs is lower (higher) than the landlord's. Similarly, for output, the effects will be positive if the peasant's desired level of output is lower than the landlord's and will be negative otherwise.

We also have limited information which may be associated with reputation effects and repeated interaction: this is constituted by a dummy variable which indicates whether the two parties to the tenancy contract in the current season were linked by the same form of contractual relationship during the previous season.[12] Again since the peasant's desired level of inputs and output can be higher or lower than the landlord's, the direction of the effects of this variable on inputs and output are generally unclear.

The fourth set of variables we consider are those which describe the quality of the plot of land in question. We observe the type of soil (clay, red earth, sandy, or barren), and whether the plot is irrigated. The fifth set of variables which may affect input and output intensities are household characteristics, availability of credit, input prices, off-farm employment opportunities, and other local economic conditions. These variables will be

[11] Supervisory activities by landlords have been examined by Lucas (1979), Alston, Datta and Nugent (1984), Alston and Higgs (1982), and Nabi (1986).

[12] Repeated interaction between landlord and tenant has been examined by Johnson (1950) and Newberry (1975); Bardhan (1984, Ch. 8) offers a simple exposition in the context of a two-period model, while Dutta, Ray, and Sengupta (1989) consider the infinite-horizon case; also see Linhart, Radner, and Sinden (1991). Robertson (1987) provides some fascinating (sub-Saharan) African evidence on the dynamics of tenancy contracts. Note that family ties between landlord and tenant might also reduce the incidence of the moral hazard problem, although most inhabitants of El Oulja share the same (extremely) small set of surnames. The evidence along these lines goes back to Ely and Galpin (1919): also see Finkler (1978) on this topic.

controlled for through a household-specific fixed effect, as will become apparent below.

The last set of variables are inputs and output. The factor inputs included in our dataset are: (i) land; (ii) male family labor; (iii) female family labor; (iv) male hired labor; (v) female hired labor; (vi) irrigation; (vii) plowing; (viii) fertilizer (animal manure), insecticides, pesticides, herbicides, and sulfur; (ix) transportation; (x) chemical fertilizer (regular phosphates, super phosphates and amonitre); (xi) harvesting; and (xii) seeds. There is a good deal of variation in these variables, as can be seen from Table 2. This allows us to identify the effects of the variables described above on inputs and output. Furthermore, except for output, land, and male family labor, which are always strictly positive, other inputs are often not used. Table 3 gives the percentage of plots on which each of these other inputs is not used. As can be gleaned from the table, the percentage of censored variables ranges from 2.8% for plowing to 82.8% for harvesting. Such high censoring frequencies require added attention in the choice of empirical methodology.

3. Empirical Implementation

Let D denote a vector of management inputs, Q a vector representing the characteristics of land, L plot size, $\tilde{X}$ a vector of other effective inputs (labor, fertilizer, etc.), and let $F(D,Q,L,\tilde{X})$ denote the production function. Let X denote observed inputs, and let M denote a vector of landlord monitoring variables. Suppose that the landlord's monitoring technology is given by $\tilde{X} = H(X,M)$.[13] When the monitoring technology is perfect, $H(X,M) = X$. Let α denote the revenue share and β the vector of cost shares accruing to the tenant. Let ω denote the opportunity cost of observed inputs X and suppose that the price of the output is normalized to one. Then, given the terms of the contract

[13] This type of specification follows Eswaran and Kotwal equations (1) and (2), pp. 354-355. Note that Eswaran and Kotwal implicitly assume that the cost-sharing and output-sharing ratios are equal, thus disposing of the traditional form of Marshallian inefficiency altogether.

(D,Q,L,α,β), and given M, the first order condition (FOC) solved by the tenant in the Marshallian case is given by:

(1) $$\frac{\partial (H(X,M))'}{\partial X}\left(\frac{\partial F(D,Q,L,\tilde{X})}{\partial \tilde{X}}\right)=\left(\frac{\beta}{\alpha}\right)*\omega,$$

while the FOC solved by the tenant in the Cheungian case or by an owner-operator is

(2) $$\frac{\partial F(D,Q,L,X)}{\partial \tilde{X}}=\omega,$$

where "*" denotes the element-by-element matrix product.

Our test for Marshallian inefficiency is based on equations (1) and (2). Let

(3) $$X^*=f(D,Q,L,M,(\beta/\alpha),\omega)$$

denote the solution to equation (1). Then, $X^*=f(D,Q,L,M,1,\omega)$ solves equation (2), if and only if $H(X,M)=X$, where 1 denotes a vector of ones. In other words, the Marshallian inefficiency problem arises when the landlord's monitoring technology is not perfect or when the output and cost shares are not equal.[14] Testing whether $f(.)$ is independent of β/α and M is therefore equivalent to testing the Cheungian *versus* the Marshallian point of view. The "unmarketed inputs" hypothesis, for its part, is rejected if $f(.)$ is independent of landlord-provided management inputs D. In what follows, we implement this methodology by specifying equation (3) parametrically.

Let $g_i(\omega)$ $(i=1,2,3)$ denote unrestricted functions of ω, u_i $(i=1,2,3)$ random shocks, and $\lambda_{ij}\,(i=1,2,3, j=0,\ldots,5)$ parameter vectors. Let $X=(X_1,X_2)$, where X_1 denotes observed male family labor input and X_2

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[14] Thus Marshallian inefficiency may still obtain when the output and cost shares are the same but monitoring is not perfect, contrary to the arguments of Schickele (1941), Heady (1947), and Adams and Rask (1968). Also see Ladejinsky (1977) and Rudra (1975).

denotes all remaining observed inputs. Since observed inputs are always non-negative, and since equation (3) can yield a negative solution, we must have $X = \max\{X^*, 0\}$. Assume that the productivity of male family labor is always sufficiently high that X_1^*, the first element of X^*, is always strictly positive. Then, we have $X_1 = X_1^*$, and our parametrization of the logarithm of the input intensity of male family labor, $\ln(X_1^* / L)$, is given by:

$$(4) \quad \ln\left(\frac{X_1}{L}\right) = \lambda_{10} + g_1(\omega) + D'\lambda_{11} + Q'\lambda_{12} + \ln(L)\lambda_{13} + (\ln(\beta / \alpha))'\lambda_{14} + M'\lambda_{15} + u_1.$$

Let X_2^* denote the remaining elements of X^*. Then $X_2 = X_2^*$ if $X_2^* > 0$, while $X_2 = 0$ otherwise. Alternatively, this may be expressed as $\ln(X_2 / L + 1) = \ln(X_2^* / L + 1)$ if the right-hand-side (RHS) is non-negative, while $\ln(X_2 / L + 1) = 0$ otherwise. Our parametrization of $\ln(X_2^* / L + 1)$ is then given by:

$$(5) \quad \ln\left(\frac{X_2}{L} + 1\right) = \begin{cases} \lambda_{20} + g_2(\omega) + D'\lambda_{21} + Q'\lambda_{22} + \ln(L)\lambda_{23} \\ \qquad + (\ln(\beta / \alpha))'\lambda_{24} + M'\lambda_{25} + u_2 \; \textit{if RHS} \geq 0 \\ 0 \; \textit{otherwise} \end{cases}$$

Equation (5) corresponds to a tobit model.[15] Substitution of equation (3) into the production function yields a reduced form for output (Y) which is parametrized by:

$$(6) \quad \ln\left(\frac{Y}{L}\right) = \lambda_{30} + g_3(\omega) + D'\lambda_{31} + Q'\lambda_{32} + \ln(L)\lambda_{33} + (\ln(\beta / \alpha))'\lambda_{34} + M'\lambda_{35} + u_3.$$

Equations (4), (5) and (6) constitute the basis for our test of Marshallian inefficiency which is equivalent to the null hypothesis $\lambda_{14} = \lambda_{15} = 0$, $\lambda_{24} = \lambda_{25} = 0$ and $\lambda_{34} = \lambda_{35} = 0$. The unmarketed inputs hypothesis is tested by the null $\lambda_{11} = \lambda_{21} = \lambda_{31} = 0$. Since our data include observations from both the 1986 and 1993 surveys, we will add a time dummy t to (4), (5) and (6).

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[15] Although we confine our presentation to a log-linear form, we also estimated using a linear specification. Results did not differ substantially enough to warrant their inclusion.

Equations (4), (5) and (6) merit further discussion. First, ω, the vector of opportunity costs of factor inputs, may be divided into two parts. On the one hand, the price of a number of inputs, such as chemical fertilizer, are set by government authorities and will therefore be common to all households. On the other hand, the opportunity cost of some inputs, such as family labor, may depend upon household characteristics when markets are imperfect. A typical example would be female family labor, where the opportunity cost of working in agriculture will reflect foregone home production.[16] The vector ω may therefore depend on household characteristics which vary across households. It will be constant across plots, however, for a given household.

Second, although equations (4) and (5) follow from (1), it may be the case that profit maximizing behavior by the households is subject to additional constraints. For example, credit constraints (e.g. Feder (1985), Laffont and Matoussi (1995)) may result in FOCs of the form:

(1')
$$\frac{\partial (H(X,M))'}{\partial X}\left(\frac{\partial F(D,Q,L,\tilde{X})}{\partial \tilde{X}}\right)=\left(\frac{\beta}{\alpha}\right)*\omega+\eta,$$

(2')
$$\frac{\partial F(D,Q,L,X)}{\partial \tilde{X}}=\omega+\eta,$$

where η represents the effects of the constraint on input choice. Then $f(.)$ will be a function of η. Although it is conceivable that all of the λ_{ij} parameters could be functions of η, this would render estimation infeasible. We will therefore impose the restriction that η is absorbed by λ_{10}, λ_{20} and λ_{30} in equations (4), (5) and (6): λ_{10}, λ_{20} and λ_{30} will therefore vary across households but will be constant across all plots cultivated by a given household. So as to simplify notation let $\mu_k=\lambda_{k0}+g_k(\omega)$, $k=1,2,3$.

Let h index households and p index plots. Let $W=(D',Q',\ln(L),(\ln(\beta/\alpha))',M',t)'$, $\theta_k=(\lambda_{k1}',\lambda_{k2}',\lambda_{k3}',\lambda_{k4}',\lambda_{k5}',\lambda_{k6}')'$, and let Z_k denote the

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16 The opportunity cost of male family labor may also depend upon household characteristics when outside employment opportunities are constrained by seasonal considerations. The same may be said of manure or domestically produced seeds.

corresponding dependent variable, $k=1,2,3$. Let μ_{kh} denote the value of μ_k associated with household h. Let W_{ph} and Z_{kph} denote the values of W and Z_k corresponding to plot p cultivated by household h. Then equations (4) and (6) can be rewritten as:

$$(7) \qquad Z_{kph} = \mu_{kh} + W'_{ph}\theta_k + u_{kph}, \; k = 1 \; and \; 3.$$

Equation (7) is a standard panel regression model with fixed effects. Since the fixed effect μ_{kh} is constant across plots for each household, and since the households in our dataset cultivate at least twc plots, we estimate θ_k using the standard panel approach (Chamberlain (1983)).[17] Equation (5) can be written as

$$(8) \qquad Z_{2ph} = \begin{cases} \mu_{2h} + W'_{ph}\theta_2 + u_{2ph} & if \; RHS \geq 0 \\ 0 \; otherwise \end{cases}$$

Equation (8) corresponds to a fixed effects panel tobit model, which will be estimated using the trimmed least absolute deviation (LAD) estimator suggested by Honoré (1992).[18]

4. Empirical Results

Our main empirical results for all crops for household-specific fixed effects panel estimation based on the 1986 and 1993 samples are presented in Table 4. Because trimmed LAD estimation of the fixed-effects tobit model for the harvesting input did not converge, the results for this input are not reported.[19] Also, since the directions of the effects of the

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[17] Note that our household fixed-effect estimation strategy is robust to non-separability of consumption and production decisions in the context of a household model. This is because the household-specific characteristics which would affect the input intensity equations in the case of a non-separable model will be differenced out through μ_{kh}. See Benjamin (1992) for a recent exposition.

[18] Also see Powell (1986).

[19] The trimmed LAD estimation procedure throws out those observations corresponding to a pair of plots cultivated by the same household if the input in question is zero on both plots. Thus, if this input displays a high frequency of zeroes (and harvesting displays the highest number of censored observations among all inputs), and since most regressors are

management inputs, the ratios of the cost shares to output share, and the supervisory and repeated interaction variables are not clear, as shown above, we will largely confine our discussion to the significance of these variables either individually or as groups. In particular, we will focus on those regressors that are linked to the debate surrounding Marshallian inefficiency and the relevance of moral hazard.

Output

The first striking aspect of the output intensity results presented in Table 4 is the lack of explanatory power of the contractual variables: none of the cost-sharing variables is individually significant even at the five percent level. This is confirmed by the joint hypothesis tests presented in the highlighted rows of Table 4. The χ^2 test statistic for the joint significance of the cost-sharing variables is 12.33 which is insignificant at the 5 % level. Output intensity is a decreasing function of the frequency of visits by the landlord (a higher value of this variable represents less frequent visits, see Table 2), suggesting that the peasant's desired level of output is higher than landlord's. It may also be the case that the landlord's visits constitute "firefighting," in that he visits the peasant when he hears of or suspects that there are problems. The repeated interaction variable is not significant, but the χ^2 test statistic for the joint test on the supervisory and repeated interaction variables is 31.15, which is significant at the 1 % level.

The management inputs also lack explanatory power: only the timing and type of plowing is significant at the 5 % level, while the joint hypothesis test statistic is 8.34 which is not significant at the 5 % level. This result does not support the "unmarketed inputs" model of Eswaran and Kotwal (1985) in which the management inputs are one of the key elements driving their results. The main determinants of output intensity thus appear to be the characteristics of land as indicated by the highly significant coefficients on soil type and the irrigated plot dummy. There also appears

dummies or discrete, these regressors will become constant or perfectly collinear once those pairs are deleted. This will lead to difficulty in identifying the parameters and in the convergence of the estimation.

to be a small, but highly significant, inverse relationship between plot size and output per hectare which is familiar from a number of studies.[20]

The lack of significance of the cost-shares implies that the incentive effects of contracts are not a significant determinant of output per hectare, while the joint significance of repeated interaction and supervision implies that landlord monitoring was partial. It may be the case that the threat of contract termination provides sufficient incentives to induce the desired level of output, regardless of the form taken by the cost-sharing arrangements. Therefore, the pure Cheungian view is rejected in favor of Marshallian inefficiency.

The lack of significance of the contract terms may stem from a number of factors. First, it is possible that the productivity and likely level of non-observable effort of tenants in El Oulja are known to all the relevant parties. Second, it may be the case that all of the potential tenants have been sorted according to their known capabilities. The best tenants are rewarded by being placed on the most productive land. Thus, even if there is a relatively homogeneous contract for all sharecropped plots, this arrangement is most beneficial to those tenants who possess the greatest skills and who work hardest. It may be the prospect of being allowed to cultivate the best plots of land that motivates the tenants to toil diligently even if monitoring by landlords is imperfect. Third, there may be self-monitoring by the various members of the tenant's family on sharecropped plots. This "team" aspect of production, and the usual argument that internal monitoring is more effective the smaller the number of parties involved or the closer their proximity while working, is consistent with our finding that output per hectare is significantly and inversely related to plot size. Moreover, smaller plots in El Oulja tend to be closer to the center of the village than larger plots: they are thus inherently easier to monitor.

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[20] See Bardhan (1973), Berry and Cline (1979), Deolalikar (1981), as well as Rao and Chotigeat (1981).

Male family labor

In the case of the male family labor intensity results presented in Table 4, none of the cost-sharing, supervisory, or repeated interaction variables are individually significant even at the five percent level. The null hypothesis of the joint significance of these variables is also rejected, suggesting that the Marshallian hypothesis is rejected in favor of its Cheungian alternative. Several management inputs, on the other hand, are significant individually. They are also jointly significant. This supports the "unmarketed inputs" hypothesis. Note that some management inputs have positive effects while others have negative effects. Since pure agricultural management by landlords would increase input intensity, negative coefficients on some of these variables implies that they are capturing some aspects of landlord monitoring as well. We interpret this as evidence for partial monitoring and hence reject the Cheungian view in favor of Marshallian inefficiency.

Other inputs

The results for the other input intensity equations are more revealing. Broadly speaking, we can divide the other inputs into three categories, based upon the χ^2 tests for the joint significance of different sets of regressors. First, the joint tests for the significance of the cost sharing variables are rejected at the 1 % level only for chemical fertilizer. Thus, the terms of the contract play a significant role in the determination of the intensity of all other inputs apart from chemical fertilizer. Second, the management variables are jointly significant at the 1% level for female hired labor, plowing and manure/pesticides/herbicides. Thus, the "unmarketed inputs" hypothesis receives partial support. Third, the supervisory and repeated interaction variables are jointly significant at the 1% level for all inputs except hired male labor, transportation and seeds. These results lead us to reject the Cheungian view in favor of Marshallian inefficiency. Note that the repeated interaction variable is significant at the 5% level only for plowing and manure. This casts doubt on whether repeated interaction *per se* plays any major role in circumventing the problem of moral hazard within a given landlord-tenant pair for the input in question, although it may still play a role in conveying information regarding tenants among landlords.

Wheat and other grain subsample

There is a substantial body of empirical evidence on differences in output and input intensities by contractual status which suggests that differences in crop mix may have a significant impact on our results. This stems in part from the type of crop being grown under sharecropping *versus* those being grown under fixed rental contracts, as well as differences in the underlying technological choices.[21] The potential problem with our previous estimating equations is most readily seen by noting that we are implicitly assuming: (i) that the production technologies are shared by all crops being grown, and (ii) that differences in the prices paid for the different crops being grown are unimportant.

In order to test the robustness of our results to these concerns, we estimate our output and input intensity equations on a subsample of 114 plots which are cultivated solely in wheat and other grains. Given that these grains are almost entirely destined for market, we are thus able to circumvent problems stemming from the "low value staple" *versus* "high value market" crop dichotomy which has been noted in a number of empirical studies (see, e.g. Bharadwaj (1974) and Kutcher and Scandizzo (1976)). Results for the wheat and other grain subsample are presented in Table 5.

In the case of the grain subsample, none of the management input coefficients can be identified because these variables are constant for each given household and thus are absorbed into the household specific effects.[22] There is also perfect multicollinearity among the ratios of cost shares to output share: therefore, only a subset of these ratios were used in the

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21 There may also be differences in the production technologies used, by contractual type. For example, Heady (1955), Junankar (1976), Bagi (1981), find significant differences in the production technologies used on sharecropped versus owner-operator and fixed rent land.

22 This also suggests that the technology used in grain production is common to all households since it calls upon the same mix of landlord-provided management inputs.

estimation. Further, trimmed LAD estimation of input equations for irrigation, female family labor, female hired labor, and harvesting did not converge and therefore the results for these inputs are not reported (for the explanation, see n.19). For many inputs, and most interestingly for output, several cost-sharing variables are highly significant. Thus, the Cheungian hypothesis is rejected for the grain subsample, even when one considers the output and male family labor equations.

The grain subsample also brings results regarding landlord supervision and repeated interaction into sharper focus. The frequency of landlord visits is significant and increases input intensity (meaning that its coefficient is negative) for male family labor, plowing, manure, transportation, and chemical fertilizer. Repeated interaction also has a significant and positive effect for the same inputs. Repeated interaction and landlord supervision are thus much more present as a significant explanatory variables when one restricts one's attention to the grain subsample than when one considers the sample consisting of all crops. Indeed, it is only in the case of male hired labor that the supervision and repeated interaction variables are jointly insignificant.

Factors associated with the production of wheat and other grains in El Oulja explain these findings. First, the average frequency of landlord visits on plots under tenancy arrangements is lower when wheat or other grains are grown (a visit once or twice during the season) than for the sample as a whole (weekly visits). This is because there is less scope for landlord supervision in wheat —landlord visits rarely occur during the growing season— than for other crops (such as vegetables). In the case of grains, landlord visits are usually associated either with plowing and planting decisionmaking, or with harvesting. It is therefore highly likely that the supervision variable in fact proxies for the management inputs provided by landlords to tenants growing wheat. Second, male hired labor in the case of wheat production is largely confined to workers who produce bales of hay on a piece-rate basis. It is thus not surprising that the terms of the contract and the supervision variables are insignificant for this input. Third, the relative unimportance of landlord supervision in wheat production, combined with the scope for moral hazard on the part of the peasant, explains why the terms of the contract are more important in determining inputs and output per hectare for wheat and other grains than for the sample as a whole.

How important is moral hazard?

Broadly speaking, our empirical results, particularly those for the other factor inputs (in the context both of the full sample and of the grain subsample), support the Marshallian view in the sense that the cost and output sharing elements of the contracts are statistically significant at the usual levels of confidence. The joint significance of the landlord-provided management inputs (in the case of the full sample) also support the unmarketed inputs model of agricultural tenancy. On the other hand, the average impact of the terms of the contract on output and input intensities is small, particularly if one considers the sample consisting of all crops, as revealed in the decompositions presented in Table 6. More interestingly, the cost- and output-sharing portion of the contract frequently *increases* input intensity. Input intensity is lower, *ceteris paribus*, on plots under tenancy contracts than under owner-operatorship for irrigation, plowing, transportation, and chemical fertilizer. The opposite is true for the male family labor, female family labor, male hired labor, female hired labor, manure, and seeds. These results highlight that, at least in El Oulja, Marshallian inefficiency is best viewed as a departure from the first best optimum attained by an owner-operator, and not as lower input intensity *per se*. Note that our results are quite different from those reported by Shaban (1987, pp. 905-8), who found sizably lower input intensities stemming from tenancy for all but one factor input (fertilizer).

Since the terms of the contract are jointly significant and reduce input intensity only in the case irrigation, plowing and transportation, it is worth asking what is particular about these inputs in El Oulja. First, inputs for which the terms of the contract are jointly significant and increase input intensity (in the full sample) —female family labor, male and female hired labor, and manure— are applied in a continuous manner during the sowing, growing and harvesting seasons for most crops. It is thus relatively difficult for the landlord, unless he is willing to pay frequent visits to the plot, to monitor their use. In contrast, plowing is by its very nature associated largely with the brief sowing season, while transportation expenses are incurred mainly in getting the harvest to market in a timely fashion. There is thus much less scope for moral hazard on the part of the tenant when it comes to the plowing and transportation inputs, and peasants will presumably attempt to substitute other less-easily monitored inputs for their undersupplied (and unobservable) effort. This would explain the higher level of input intensity on plots under tenancy arrangements for manure and the three types of labor inputs. Second, while irrigation is supplied continuously during the growing season for most crops, its use is relatively easy to monitor. In the case of government-provided "sluice" irrigation, the question of moral hazard in input use is moot since water is provided for a fixed fee per hectare for each type of crop. In the case of diesel-powered pumps, the amount of water can be inferred from the cost of fuel, although the mobility of the smaller pumps and of plastic irrigation pipes leaves room for some opportunistic behavior on the part of peasants. Thus, peasants will tend to substitute less-easily monitored inputs for low levels of unobservable effort: this explains why the input intensity of more easily monitored inputs such as plowing, transportation and irrigation will be lower on plots under tenancy, whereas the opposite will be true for less-easily monitored inputs such as labor and manure. A third piece of evidence motivated by moral hazard which lends credence to this argument is that landlords appear to be aware of the aforementioned problems and attempt (unsuccessfully) to combat them through the terms of the contract: the two lowest average cost-to-output share ratios accruing to tenants obtain in the case of plowing (0.82) and irrigation (0.85), while the fourth-lowest obtains in the case of transportation (0.88).

5. Concluding Remarks

In this paper we have considered the empirics of moral hazard in agricultural tenancy contracts, which in development economics is known as the issue of Marshallian inefficiency. Our empirical results, based upon panel estimation techniques with household fixed effects which control, in the case of several inputs, for censoring, lead us to reject the Cheungian hypothesis of perfect monitoring in favor of a version of Marshallian inefficiency which takes the importance of agricultural management, supervision, and repeated interaction into account. Our results thus lead us to the conclusion that moral hazard does matter in the context of tenancy arrangements in El Oulja.

In contrast to the substantial theoretical and empirical literature which attributes negative effects to sharecropping in terms of input intensity, we find that the terms of the contracts often result in higher input intensities on land under tenancy contracts than on land under owner-operatorship. The key to this finding is our detailed information on the managerial inputs provided by landlords, the cost-sharing elements of tenancy contracts, supervisory activities by landlords, and repeated interaction between landlords and peasants, information which, to the best of our knowledge, has not been exploited in previous empirical studies of Marshallian inefficiency. Upon reflection, this result is not surprising. Cost-sharing is tantamount to partial reimbursement to the tenant for the use of certain inputs. Since unobservable labor effort is not subject to cost-sharing, it is likely that peasants will substitute more of an input subject to cost-sharing and less-easily monitored by the landlord in order to compensate for lower levels of effort.

Despite the statistical significance of moral hazard revealed by our empirical results, we find that, in general, contract terms have a quantitatively small impact on input intensities as compared to plot characteristics. This leads us to conclude that the role of sharecropping contracts in mitigating the moral hazard problem is relatively limited, and that they may be chosen for other reasons, such as risk-sharing or transactions-costs.[23] Much of the theoretical work on sharecropping has been based on moral hazard, and our empirical results for the wheat subsample highlight that these concerns can be important for certain crops. Our results suggest that, on the theoretical side, researchers should

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[23] Risk-sharing is an admissible reason for sharecropping when the conditions are such that the well-known "equivalence result" of Newberry (1975) does not obtain. See Allen and Lueck (1995) for an exposition, as well as an empirical test of the risk-sharing *versus* transactions-cost approaches in the context of North American agricultural contracts.

incorporate direct monitoring by landlords into contractual models and explain how the terms of contracts are affected. In particular, researchers should extend the standard static model of sharecropping to dynamic multiple landlord/multiple peasant models and examine the importance of repeated interaction in determining the terms of contracts. On the empirical side, future work should focus on explaining why sharecropping contracts exist and on how the terms of contracts, particularly those concerned with cost-sharing, are determined.

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Table 1
Distribution of cost share-output share ratio (β_i / α), by factor input i

β_i / α by factor input	0	0.66	0.75	1	1.33	1.5	2
Percentage of fertilizer, herbicide and insectide costs paid by peasant	0.8	na	0.4	91.4	4.9	1.9	0.8
Percentage of irrigation costs paid by peasant	14.0	na	na	81.1	2.6	1.9	0.4
Percentage of family labor costs paid by the peasant	0.4	na	na	56.7	5.0	3.7	34.1
Percentage of hired labor costs paid by the peasant	1.5	na	na	56.4	4.9	3.0	34.1
Percentage of plowing costs paid by peasant	44.0	1.00	na	48.8	3.4	1.0	1.9
Percentage of seed costs paid by peasant	1.1	na	na	89.5	4.9	2.7	1.5
Percentage of transportation costs paid by peasant	1.9	na	na	86.1	4.9	2.3	4.9
Percentage of harvesting costs paid for by peasant	4.9	na	na	64.3	4.9	3.0	22.8
Percentage of pre-harvesting costs paid by peasant	9.9	1.9	0.8	64.6	5.7	1.5	15.5

Table 2
Description of the variables and Summary Statistics

VARIABLES		MEAN	STD. ERROR	MIN.	MAX.
Output	expressed in Tunisian dinars per hectare	4589.84	10334.10	4.00	110000
Factor inputs					
Male family labor	expressed in person-days per hectare	94.17	113.45	1.00	1134.00
Female family labor	expressed in person-days per hectare	27.22	56.94	0.00	480.00
Male hired labor	expressed in person-days per hectare	117.39	260.55	0.00	2310.00
Female hired labor	expressed in person-days per hectare	132.33	362.93	0.00	4180.00
Cost of irrigation	expressed in Tunisian dinars per hectare	277.97	629.77	0.00	9000.00
Cost of ploughing	expressed in Tunisian dinars per hectare	179.13	335.19	0.00	2880.00
Cost of manure and herbicides etc.	expressed in Tunisian dinars per hectare	177.38	423.25	0.00	4500.00
Cost of transportation	expressed in Tunisian dinars per hectare	173.36	413.18	0.00	5400.00
Cost of chemical fertilizer	expressed in Tunisian dinars per hectare	2.76	5.32	0.00	54.24
Cost of harvesting	expressed in Tunisian dinars per hectare	0.08	0.52	0.00	8.50
Cost of seeds	expressed in Tunisian dinars per hectare	0.25	0.49	0.00	6.00
Landlord management inputs					
Landlord chooses crop	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord choses the crop, equals 0 otherwise	0.13	0.33	0.00	1.00
Landlord chooses timing and type of plowing	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord choses the quantity, timing and type of plowing, equals 0 otherwise	0.15	0.35	0.00	1.00
Landlord chooses type and quantity of seeds, and the timing of sowing	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type and quantity of seeds, and the timing of sowing, equals 0 otherwise	0.09	0.28	0.00	1.00
Landlord chooses type, timing and quantity of transportation	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of transportation, equals 0 otherwise	0.07	0.26	0.00	1.00
Landlord chooses type, timing and quantity of fertilizer	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of fertilizer, equals 0 otherwise	0.09	0.28	0.00	1.00

VARIABLES		MEAN	STD. ERROR	MIN.	MAX.
Landlord chooses type, timing and quantity of manure	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of manure, equals 0 otherwise	0.08	0.27	0.00	1.00
Landlord chooses type, timing and quantity of family labor	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of family labor, equals 0 otherwise	0.03	0.17	0.00	1.00
Landlord chooses type, timing and quantity of hired labor	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of hired labor, equals 0 otherwise	0.03	0.17	0.00	1.00
Landlord chooses type, timing and quantity of irrigation	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses type, timing and quantity of irrigation, equals 0 otherwise	0.05	0.22	0.00	1.00
Landlord chooses use made of livestock	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses use made of livestock, equals 0 otherwise	0.05	0.22	0.00	1.00
Landlord chooses timing of harvesting	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses timing of harvesting, equals 0 otherwise	0.08	0.27	0.00	1.00
Landlord chooses timing and use of combine harvester	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses timing and use of combine harvester, equals 0 otherwise	0.06	0.23	0.00	1.00
Landlord chooses the proportion of total output to be sold	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord chooses the proportion of total output to be sold, equals 0 otherwise	0.09	0.29	0.00	1.00
Landlord has final say regarding decisionmaking on the plot	equals 1 when the plot is cultivated under a fixed rental or sharecropping tenancy contract and the landlord has final say regarding decisionmaking on the plot, equals 0 otherwise	0.09	0.29	0.00	1.00
Supervision and repeated interaction					
Contract with same landlord in previous season	equals 1 when the plot is under a fixed rental or sharecropping tenancy contract and the tenant had the same contractual relationship with the same landlord in the previous growing season, equals 0 otherwise	0.22	0.41	0.00	1.00
Supervision by the landlord	for plots under sharecropping or fixed rental contracts: 1 = every day, 2 = twice a week, 3 = once a week, 4 = once or twice a month, 5 = once or twice a season, 6 = not at all; equals 0 otherwise	1.42	2.25	0.00	6.00

VARIABLES		MEAN	STD. ERROR	MIN.	MAX.
Terms of the contract					
Percentage of pre-harvesting costs paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	90.48	23.52	0.00	100.00
Percentage of harvesting costs paid for by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	93.01	20.36	0.00	100.00
Percentage of manure, herbicide and insectide cost paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	88.69	21.17	0.00	100.00
Percentage of irrigation cost paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	85.29	28.43	0.00	100.00
Percentage of family labor cost paid by the peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	96.60	12.59	25.00	100.00
Percentage of hired labor cost paid by the peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	96.39	14.01	0.00	100.00
Percentage of ploughing cost paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	82.41	34.90	0.00	100.00
Percentage of seed cost paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	89.13	20.88	0.00	100.00
Percentage of transportation cost paid by peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators	88.96	21.78	0.00	100.00
Percentage of principal crop accruing to the peasant	for plots under sharecropping or fixed rental contracts only; equals 100 for owner-operators and tenants under fixed rental contracts	87.95	21.17	25.00	100.00
Characteristics of land					
Clay soil	equals 1 when soil is clay, zero otherwise	0.27	0.44	0.00	1.00
Red earth	equals 1 when soil is "red earth", zero otherwise	0.13	0.34	0.00	1.00
Sandy soil	equals 1 when soil is sandy, zero otherwise	0.49	0.50	0.00	1.00
"Barren" soil	equals 1 when soil is "barren", zero otherwise	0.10	0.29	0.00	1.00
Irrigated plot	equals 1 when the plot is irrigated, zero otherwise	0.92	0.27	0.00	1.00
Plot area	surface of the plot in hectares	14.80	32.75	0.20	500.00

Table 3
Percentage of censored dependent variables, by factor input

Factor input	Percentage of censored dependent variables
Female family labor	56.8
Female hired labor	54.1
Male hired labor	32.8
Manure, herbicides and insecticides	29.3
Chemical fertilizers	5.9
Irrigation	14.1
Plowing	2.8
Transportation	12.7
Harvesting	82.8
Seeds	8.5

Table 4. Input and Output Intensity Equations: Full Sample

(absolute value of t-statistics in parentheses)

	Output	Male family labor	Female family labor	Male hired labor	Female hired labor
Choice of crop	0.283	0.729*	0.053	-0.023	-0.102
	(0.847)	(2.059)	(1.436)	(0.217)	(0.999)
Choice of plowing	1.009*	1.267*	-0.056	-0.082	-0.058
	(2.116)	(2.511)	(0.315)	(0.769)	(0.905)
Choice of irrigation	-0.358	0.799	0.095	0.261	0.112*
	(0.826)	(1.742)	(0.405)	(0.633)	(1.987)
Final decisionmaking on plot	-0.289	-1.221**	-0.069	-0.377	-0.232*
	(0.675)	(2.698)	(0.661)	(1.509)	(2.350)
Proportion of output to be marketed	-0.380	-1.588**	-0.030	0.266	0.086
	(0.777)	(3.069)	(0.161)	(1.391)	(0.752)
Joint signif. of landlord management $\chi^2(5)$	**8.34**	**23.12****	**12.11***	**3.33**	**31.48****
Repeated interaction	0.069	-0.113	0.039	-0.003	-0.018
	(0.352)	(0.544)	(1.128)	(0.036)	(0.498)
Frequence of visits by landlord	0.145**	0.039	0.002	0.021	0.020
	(4.468)	(1.127)	(0.611)	(1.482)	(1.867)
Joint signif. of super. & repeated inter. $\chi^2(2)$	**31.15****	**1.56**	**65.00****	**7.86***	**40.79****
Percentage of pro-harvesting costs	-0.046	-0.200	0.066	-0.057	0.007
	(0.375)	(1.525)	(1.679)	(1.108)	(0.301)
Percentage of harvesting costs	0.017	0.028	0.072*	-0.031	-0.090
	(0.085)	(0.131)	(2.397)	(0.476)	(3.615)
Percentage of fertilizer, herbicide and insecticide costs	1.148	0.331	-0.057	0.030	-0.087
	(1.148)	(0.313)	(0.159)	(0.031)	(0.747)
Percentage of irrigation costs	0.182	0.181	0.023	0.007	0.016
	(1.883)	(1.775)	(0.513)	(0.063)	(1.616)
Percentage of family labor costs	0.618	0.248	0.218	-0.092	0.158
	(1.209)	(0.458)	(1.370)	(0.801)	(1.662)
Percentage of hired labor costs	0.230	0.178	-0.070	0.388*	0.200**
	(0.783)	(0.573)	(1.570)	(1.994)	(4.676)
Percentage of plowing costs	-0.056	-0.091	-0.029	0.042	0.021
	(0.564)	(0.864)	(0.956)	(0.871)	(1.413)
Percentage of seed costs	-0.586	-0.087	-0.039	0.353	-0.019
	(0.528)	(0.074)	(0.078)	(0.631)	(0.126)
Percentage of transportation costs	0.033	0.205	-0.086	0.134	0.415**
	(0.087)	(0.513)	(1.807)	(0.284)	(2.727)
Joint signif. of the terms of the contract $\chi^2(9)$	**12.33**	**9.68**	**160.13****	**115.46****	**61.20****
Clay soil	-1.209*	0.065	0.111	-0.014	-0.042
	(2.564)	(0.130)	(1.879)	(0.178)	(0.478)
Red earth	-1.012*	-0.128	0.007	0.020	-0.050
	(2.132)	(0.252)	(0.060)	(0.291)	(0.767)
Sandy soil	-1.330**	-0.145	0.114*	-0.052	-0.113
	(2.862)	(0.294)	(2.239)	(0.749)	(2.899)
"Barren" soil	-0.835	-0.042	0.069	0.012	
	(1.728)	(0.082)	(0.797)	(0.221)	
Irrigated plot	1.941**	2.198**	0.207**	0.209**	0.223**
	(11.275)	(12.062)	(6.021)	(2.775)	(3.341)
Plot area	-0.242**	-0.663**	-0.042**	-0.058**	-0.013
	(4.309)	(11.14)	(2.697)	(3.302)	(1.011)
Year	2.394*	0.863**	0.078	0.151**	0.194**
	(13.558)	(4.616)	(1.512)	(3.307)	(2.883)

Note: 589 observations. Output and male family labor equations are log-linear panel regressions with household-specific fixed effects. All other inputs are log-linear trimmed LAD panel regressions with household fixed effects which control for censoring of the dependent variable. Barren soil dummy for femal hired labor could not be identified and its effect is thus absorbed into the other soil dummies.

*: significant at the 5% level; **: significant at the 1% level.

Table 4 (continued). Input and Output Intensity Equations: Full Sample

(absolute value of t-statistics in parentheses)

	Irrigation	Plowing	Manure, pesticides, etc.	Transportation	Chemical fertilizer	Seeds
Choice of crop	0.104	0.020	0.064	-0.015	0.090	0.047
	(1.913)	(1.108)	(0.459)	(0.145)	(0.612)	(1.146)
Choice of plowing	0.128	0.004	-0.241*	0.194	0.059	0.077
	(0.994)	(0.385)	(2.437)	(1.615)	(0.443)	(0.784)
Choice of irrigation	0.021	0.075**	0.133	0.045	0.153	0.063
	(0.317)	(4.630)	(1.591)	(0.398)	(1.335)	(0.772)
Final decisionmaking on plot	-0.200*	-0.116**	-0.071	-0.127	-0.458	-0.091
	(2.435)	(7.840)	(0.682)	(1.104)	(1.501)	(0.672)
Proportion of output to be marketed	-0.084	0.007	0.126	-0.027	0.029	0.110
	(0.510)	(0.334)	(1.091)	(0.306)	(0.095)	(1.379)
Joint signif. of landlord management $\chi^2(5)$	9.17	27.70**	25.03**	5.90	8.49	6.68
Repeated interaction	0.083	0.038*	-0.101*	0.028	0.085	-0.050
	(1.118)	(2.177)	(2.261)	(0.582)	(1.118)	(0.576)
Frequence of visits by landlord	0.016*	-0.002	-0.001	-0.007	0.032*	0.008
	(2.197)	(0.852)	(0.116)	(0.488)	(2.293)	(0.866)
Joint signif. of super. & repeated inter. $\chi^2(2)$	24.64**	138.29**	25.22**	6.43*	32.35**	8.31*
Percentage of pre-harvesting costs	-0.062**	-0.029**	-0.058**	0.006	-0.022	0.041
	(3.412)	(3.285)	(3.673)	(0.169)	(0.646)	(1.275)
Percentage of harvesting costs	-0.02	-0.006	-0.007	-0.010	0.043	-0.007
	(0.421)	(0.842)	(0.263)	(0.235)	(0.309)	(0.173)
Percentage of fertilizer, herbicide and insecticide costs	0.446**	-0.065	-0.351	-0.281	-0.127	0.285*
	(3.077)	(1.131)	(1.051)	(0.487)	(0.570)	(2.252)
Percentage of irrigation costs	0.007	-0.007*	-0.005	0.040*	-0.008	-0.072**
	(0.437)	(2.012)	(0.103)	(2.064)	(0.369)	(3.455)
Percentage of family labor costs	-0.179*	-0.128**	-0.016	0.199	-0.305*	0.018
	(2.323)	(4.619)	(0.125)	(1.428)	(2.073)	(0.211)
Percentage of hired labor costs	0.099	0.045**	0.121**	0.066	0.061	-0.063
	(1.712)	(5.125)	(3.384)	(0.999)	(0.255)	(0.835)
Percentage of plowing costs	-0.016	-0.009	-0.021	0.038*	-0.016	0.008
	(0.869)	(1.935)	(0.357)	(2.468)	(0.422)	(0.337)
Percentage of seed costs	-0.498	-0.061	0.331	-0.241	-0.203	-0.204
	(1.736)	(0.740)	(1.345)	(0.517)	(0.708)	(1.099)
Percentage of transportation costs	0.085	0.044**	0.137**	0.136	0.079	-0.151
	(1.258)	(4.344)	(2.781)	(1.326)	(0.266)	(1.700)
Joint signif. of the terms of the contract $\chi^2(9)$	29.31**	58.24**	67.39**	77.01**	14.43	78.52**
Clay soil	-0.097	0.020	0.054	0.020	-0.290	0.142
	(1.189)	(0.802)	(0.737)	(0.281)	(1.274)	(1.759)
Red earth	0.037	0.030	0.054	0.031	-0.289	0.117
	(0.329)	(1.112)	(0.540)	(0.347)	(1.130)	(1.940)
Sandy soil	-0.055	0.012	0.013	-0.050	-0.341	0.181
	(0.823)	(0.398)	(0.163)	(0.600)	(1.372)	(1.776)
"Barren" soil	0.025	0.049	0.079	0.083	-0.281	0.229*
	(0.361)	(1.939)	(0.844)	(0.811)	(1.218)	(2.293)
Irrigated plot	0.246**	0.013	0.246**	0.229**	0.353**	0.231**
	(4.025)	(1.529)	(2.861)	(2.643)	(2.788)	(4.296)
Plot area	-0.057**	0.002	-0.019	-0.065*	-0.059	-0.051
	(3.495)	(0.599)	(0.967)	(2.167)	(1.275)	(1.823)
Year	0.281**	0.164**	0.377**	0.228**	1.002**	0.358**
	(5.099)	(7.245)	(3.227)	(3.169)	(8.752)	(5.191)

Note: 589 observations. Output and male family labor equations are log-linear panel regressions with household-specific fixed effects. All other inputs are log-linear trimmed LAD panel regressions with household fixed effects which control for censoring of the dependent variable. Barren soil dummy for female hired labor could not be identified and its effect is thus absorbed into the other soil dummies.

*: significant at the 5% level; **: significant at the 1% level.

Table 5.
Input and Output Intensity Equations: Wheat and other grain subsample
(absolute value of t-statistics in parentheses)

		Output	Male family labor	Male hired labor	Plowing	Manure, pesticides, etc.	Transportation	Chemical fertilizer	Seeds
Repeated interaction		0.223	3.202*	-0.011	0.116**	0.080**	0.293**	0.585**	-0.022
		(0.178)	(2.413)	(1.629)	(6.369)	(5.916)	(7.958)	(6.067)	(0.801)
Frequence of visits by landlord		0.020	-0.438*	0.001	-0.019**	-0.013**	-0.056**	-0.095**	0.000
		(0.103)	(2.118)	(1.363)	(3.320)	(3.935)	(10.94)	(4.557)	(0.089)
Joint signif. of super. & repeated inter.	$\chi^2(2)$	0.74	7.28*	2.17	42.22**	33.93**	86.36**	36.86**	1.33
Percentage of plowing costs		-0.631	-0.752	-0.027	-0.120	-0.091	-0.120	-0.152	0.002
		(1.661)	(1.877)	(0.002)	(3.276)	(5.256)	(14.81)	(4.442)	(0.557)
Percentage of family labor costs		0.656	0.327	0.022	-0.001	-0.003	0.105	0.000	0.028
		(0.701)	(0.332)	(0.002)	(0.015)	(0.192)	(16.573)	(0.001)	(7.527)
Percentage of hired labor costs		1.692	0.136	0.010	-0.123	-0.010	-0.453	-0.551	-0.044
		(1.440)	(0.109)	(0.001)	(2.938)	(0.620)	(12.46)	(4.316)	(2.538)
Percentage of seed costs		6.092	7.349	0.029	0.804	0.328	0.987	1.306	0.029
		(2.523)	(2.884)	(0.001)	(2.835)	(7.375)	(8.757)	(5.120)	(0.920)
Percentage of harvesting costs		-2.923	-4.626	0.011	-0.552	-0.226	-0.332	-0.513	0.043
		(1.649)	(2.473)	(0.001)	(2.704)	(4.638)	(5.488)	(1.714)	(1.837)
Joint signif. of the terms of the contract	$\chi^2(5)$	23.34**	12.89*	3.23	354.6**	218.9**	795.8**	42.23**	54.31**
Clay soil		-0.771	0.258	0.007	-0.017	-0.010	-0.019	-0.350	0.028
		(1.265)	(0.402)	(0.976)	(0.563)	(0.633)	(1.689)	(2.693)	(1.848)
Red earth		-1.054	0.097	-0.002	-0.013	-0.004	-0.022	-0.532	0.019
		(1.875)	(0.163)	(0.485)	(0.462)	(0.312)	(4.190)	(4.885)	(0.854)
Sandy soil		-0.912	-0.211	0.007	-0.018	-0.019	-0.014	-0.382	0.026
		(1.551)	(0.340)	(0.985)	(0.576)	(1.965)	(1.147)	(2.908)	(1.502)
"Barren" soil		-1.217	-1.123	0.000	0.001	-0.018	-0.016	-0.425	0.010
		(1.802)	(1.576)	(0.020)	(0.056)	(1.125)	(2.359)	(3.025)	(0.510)
Irrigated plot		1.061	1.047	0.013	-0.008	0.006	0.000	-0.054	0.000
		(5.253)	(4.909)	(4.008)	(1.058)	(1.703)	(0.161)	(3.103)	(0.046)
Plot area		-0.750	-0.853	-0.002	-0.003	-0.002	-0.001	-0.032	-0.002
		(7.776)	(8.375)	(2.075)	(1.019)	(0.703)	(0.632)	(3.320)	(1.758)
Year		2.802	-0.014	0.012	0.169	0.061	0.298	0.557	0.067
		(8.466)	(0.040)	(1.723)	(4.527)	(5.230)	(15.614)	(7.227)	(8.236)

Note: 114 observations. Output and male family labor equations are log-linear panel regressions with household-specific fixed effects.
All other inputs are log-linear trimmed LAD panels which control for censoring of the dependent variable.
*: significant at the 5% level; **: significant at the 1% level.

Table 6.
Average contributions of different groups of regressors
(average contribution, as percentage of contribution of all regressors)

	Output	Male family labor	Female family labor	Male hired labor	Female hired labor	Irrigation	Plowing	Manure, pesticides, etc.	Transportation	Chemical fertilizer	Seeds
Sample: all crops											
All regressors	1.573	1.371	0.274	0.165	0.203	0.245	0.100	0.371	0.194	0.355	0.468
Landlord management inputs	0.100	0.062	-0.005	-0.011	-0.028	0.007	-0.003	-0.014	0.014	-0.011	0.216
	6.4%	4.5%	-1.8%	-6.7%	-13.9%	2.9%	-2.7%	-3.8%	7.3%	-3.0%	46.2%
Supervision and repeated interaction	0.220	0.030	0.006	0.019	-0.003	0.048	0.002	-0.379	0.010	0.054	0.023
	14.0%	2.2%	2.3%	11.3%	-1.7%	19.7%	2.4%	-102.2%	5.4%	15.2%	4.8%
Terms of the contract	0.088	0.067	0.022	0.014	0.019	-0.005	-0.005	0.026	-0.006	-0.024	0.005
	5.6%	4.9%	8.0%	8.4%	9.5%	-1.9%	-4.6%	7.0%	-2.9%	-6.8%	1.2%
Characteristics of land	1.165	1.212	0.251	0.143	0.216	0.194	0.105	0.738	0.175	0.336	0.224
	74.1%	88.4%	91.5%	86.9%	106.0%	79.3%	104.9%	199.1%	90.3%	94.6%	47.8%
Sample: wheat and other grains											
All regressors	-1.105	-1.362	n.a.	0.013	n.a.	n.a.	0.010	0.001	0.046	-0.371	0.032
Supervision and repeated interaction	0.062	0.132	n.a.	-0.001	n.a.	n.a.	0.001	0.001	-0.004	0.009	-0.004
	-5.6%	-9.7%	n.a.	-4.7%	n.a.	n.a.	11.1%	100.0%	-8.7%	-2.3%	-11.4%
Terms of the contract	0.078	-0.008	n.a.	0.002	n.a.	n.a.	-0.008	-0.002	-0.010	-0.019	0.001
	-7.1%	0.6%	n.a.	13.2%	n.a.	n.a.	-80.8%	-181.8%	-21.3%	5.1%	1.9%
Characteristics of land	-1.246	-1.486	n.a.	0.012	n.a.	n.a.	0.017	0.002	0.060	-0.361	0.035
	112.7%	109.1%	n.a.	91.5%	n.a.	n.a.	169.7%	181.8%	129.9%	97.2%	109.5%

Source: Tables 4 and 5; contributions evaluated at the sample means.

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