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Testing between Competing Models of Sharecropping

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The "Marshallian" approach assumes a prohibitively high cost of monitoring the sharecropper's activities while the "monitoring" approach argues that landlords stipulate and effectively monitor sharecroppers' activities. I present new evidence using detailed data collected from eight Indian villages. Most tenants own some land of their own; this provides a controlled environment in studying the impact of contractual arrangements. The differences in input and output intensities on owned minus sharecropped land of the same household are found to be sizable and significant, suggesting a rejection of the monitoring approach and supporting the notion of the "Marshallian productive inefficiency" of sharecropping.

I. Introduction

The recent theoretical literature on agricultural tenancy has followed two basic approaches to modeling sharecropping contracts. The first assumes a prohibitively high cost of monitoring the tenant's activities. This leads to the well-known indictment of "productive inefficiency" of sharecropping, based on the presumption of the tenant's application of less variable inputs to the rented land relative to alternative

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contractual arrangements. Such an approach, often called Marshallian analysis, characterizes the papers of Bardhan and Srinivasan (1971), Bell and Zusman (1976), Braverman and Srinivasan (1981), Braverman and Stiglitz (1982, 1986), and Shaban (1985).

The second approach to modeling tenancy is based on the work of Cheung (1968, 1969). It is sometimes labeled the "new school," but I will refer to it as the "monitoring approach" to sharecropping. This approach argues that landlords stipulate the intensity of labor per unit area, and they have a sufficiently inexpensive and effective monitoring ability to ensure that their stipulation is indeed fulfilled. The contract offered by the landlord would then stipulate the plot size, the tenant's share, and the intensity of cultivation. A conclusion of this analysis is that productive efficiency prevails as the intensity of cultivation and the marginal products of factors of production are equated across lands that are owned or rented, whether on a sharecropping or a fixed-rent basis. This approach was extensively developed in Newbery (1974, 1975*a*, 1975*b*, 1977) and Stiglitz (1974).

The fundamental difference between the two approaches lies in the ability of the landlord to monitor the activities of the tenant effectively. This issue can be settled only by empirical evidence. The existing evidence appears inconclusive, as I will indicate in Section IV. Further empirical analysis is needed. I present new evidence using a rich data set collected from villages in the semiarid tropics of India. The essential conclusion of this evidence is a strong rejection of the monitoring approach to modeling agricultural tenancy.

I briefly describe the data set in Section II and discuss the empirical results in Section III. In Section IV, I critically survey various empirical studies and contrast their methods with the one employed here. Section V summarizes the findings of the new evidence. The Appendix deals with potential selectivity bias in the estimation.

II. The Villages

The data set used in this paper is the rich and multipurpose village level studies (VLS) data collected by the Economics Program of the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in India. The purpose of the VLS and the method of data collection are documented in Jodha, Asokan, and Ryan (1977) and Binswanger and Jodha (1978). A description of the agroeconomic characteristics of some villages is given in Kshirsagar (1982, 1983), Singh and Singh (1982), and Bhende (1983). The features of tenancy arrangements in six of the VLS villages are analyzed and documented in Jodha (1981), and some analysis of the pattern of land leasing and input use according to tenure status is presented in Pant (1981, 1983).

Several districts were chosen to represent various agroclimatic zones in the semiarid tropical parts of India. The districts that are used in the present paper are Mahbubnagar in the state of Andhra Pradesh, Sholapur and Akola in the state of Maharashtra, and Sabarkantha in the state of Gujarat.[1] Two representative villages were selected in each district, and a randomly selected panel of 30 cultivating and 10 labor households were chosen in each village. Resident investigators collected detailed information on inputs, outputs, and various attributes of all plots in every season for all cultivating households. Information on the plot tenure status was also collected.

Table 1 presents the number of cultivating households according to tenure status in the pooled time-series, cross-section data. The table shows that agricultural tenancy is widespread: roughly one-fifth of the households are involved in sharecropping contracts, and 5 percent are involved in fixed-rent tenancy. An interesting feature of tenancy in these villages, and in India in general, is the dominance of mixed over pure tenants: 80 percent of all tenants cultivate some land that they own.[2]

In table 2, the plots of all households in all years are pooled together and characterized according to the plot's tenure status. The table shows that 15 percent of all plots are sharecropped, while 1.7 percent of all plots are cultivated under fixed-rent tenancy. The area under sharecropping is 17.5 percent of all the cultivated area in the sample, while 1.6 percent of the cultivated area is under fixed-rent tenancy. Fixed-rent tenancy is dominant in Aurapalle (village A) and is to be found in Kanzara, Boriya, and Rampura (villages E, G, and H). Sharecropping dominates tenancy arrangements in the VLS villages except in Aurapalle.

The plot values, presented in table 2, were collected from the *same* person or *same* group of knowledgeable farmers for all plots in a given village. This ensures consistent evaluation of the plots within the same village. The variable is supposed to represent "the potential sale value of the plot, including the value of the irrigation source, but excluding the pumping equipment" (Binswanger and Jodha 1978, pp. 33–34). It captures the productivity of the land as it is affected by both soil quality and whether the plot is irrigated. Note the ranking of the quality of plots by tenure status: owned plots are generally better than shared plots, which are better than plots under fixed-rent tenancy.

[1] Data collection started in the Raisen district in Madhya Pradesh in 1981, but these data were not used in this paper because of their recent collection.

[2] The exclusion of the landless labor class from the tenancy market is an important question that has been addressed by several authors (see Jodha 1981; Bliss and Stern 1982; Vaidyanathan 1982).

TABLE 1

DISTRIBUTION OF HOUSEHOLDS BY TENURE STATUS

Village	Years in Sample	Pure Owners	Pure Sharecroppers	Pure Tenants*	Mixed Owner/ Sharecropper	Mixed Owner/ Tenant	Mixed Owner/ Sharecropper/ Tenant	Total
A. Aurapalle	1975–82	368	1	13	4	20	0	406
B. Dokur†	1975–79	181	4	0	31	2	2	220
C. Shirapur	1975–82	302	46	0	87	2	0	437
D. Kalman†	1975–79	203	7	0	84	2	0	296
E. Kanzara	1975–82	258	8	3	27	14	10	320
F. Kinkheda†	1975–79	159	2	0	25	0	1	187
G. Boriya‡	1980–82	105	8	8	46	16	3	186
H. Rampura‡	1980–82	165	7	1	25	11	7	216
All villages		1,741	83	25	329	67	23	2,268
		(76.8)§	(3.7)	(1.1)	(14.5)	(3.0)	(1.0)	

NOTE.—Unit of observation is a household in a given season in a given year. Thus the same household could provide multiple observations.
* "Tenant" refers to fixed-rent tenants.
† Data were not collected in Dokur, Kalman, and Kinkheda after 1979.
‡ Data collection in Boriya and Rampura started in 1980.
§ Percentages are in parentheses.

TABLE 2

CHARACTERISTICS BY TENURE STATUS

	Owned			Sharecropped			Fixed-Rent		
Village	Number of Plots	Average Plot Area (Acre)	Average Plot Value*	Number of Plots	Average Plot Area	Average Plot Value*	Number of Plots	Average Plot Area	Average Plot Value*
A	1,249 (96.4)†	1.91	21.20	8 (.5)	1.53	13.75	38 (3.1)	2.03	14.00
B	532 (84.1)	1.55	42.15	66 (14.9)	2.22	40.23	5 (1.0)	1.90	40.00
C	1,516 (64.5)	1.57	29.68	526 (35.5)	2.49	24.86	3 (.0)	.20	21.33
D	1,472 (77.6)	1.64	17.55	351 (22.1)	1.96	13.43	2 (.3)	4.00	10.00
E	1,133 (83.9)	2.57	22.56	114 (12.3)	3.73	18.94	37 (3.8)	3.57	11.70
F	568 (92.2)	3.51	15.05	57 (7.7)	2.93	10.60	1 (.1)	2.00	10.00
G	425 (67.1)	.71	39.30	138 (25.5)	.83	39.28	46 (7.4)	.72	35.20
H	916 (80.7)	1.04	62.79	160 (16.1)	1.19	60.70	26 (3.1)	1.42	56.15
All	7,811 (80.9)	1.81	29.20	1,420 (17.5)	2.15	27.08	158 (1.6)	1.77	27.45

NOTE.—A given plot may contribute multiple observations if it is cultivated in different seasons or years. The total number of plots in the pooled cross-section, time-series sample is 9,389.
* The average plot value is measured in 100 rupees per acre.
† The numbers in parentheses are the percentage of the total area in a given row that is cultivated under the given tenure system.

The terms of the contract were not provided in the available data, but reading the investigators' worksheets of a special survey on tenancy,[3] I was impressed by the uniformity of the sharing rules of inputs and outputs in sharecropping contracts within any village. Land is provided by the landlord, and family and bullock labor are provided by the sharecropper. The dominant sharing rules in other inputs and outputs are the following.[4] Aurapalle, Shirapur, and Kinkheda: Outputs are shared equally by the landlord and sharecropper, while the costs of other inputs are fully borne by the sharecropper. Dokur: The main output and the costs of all other inputs are shared equally between the landlord and the sharecropper. The by-products, mostly fodder, are left to the sharecropper. Kalman: Main and by-products are shared equally. The costs are equally shared for fertilizers, land tax, seeds for groundnut, gram, wheat, and paddy, and the wages for hired labor if it performs weeding, harvesting, and threshing. The costs of other types of seed and hired labor and the remaining inputs are fully borne by the sharecropper. Kanzara: Main and by-products are shared equally. There is also equal sharing in the case of fertilizer, hybrid or high-quality seed, and hired labor for harvesting purposes. The costs of other types of hired labor, seed, and other inputs are borne by the sharecropper.

The only government restriction that seems to have affected tenancy in the sampled villages is the land-to-the-tiller legislation: this confers property rights on tenants who prove that they have been cultivating the land for a number of years, irrespective of the form of the contract. Apprehension about loss of land leads landlords to offer short-term contracts, normally for a season or a year.[5] This apprehension will generally lead to underreporting of tenancy, especially in government publications. The ICRISAT's VLS data set does not suffer from such a problem; it would be difficult to hide information from an investigator who lives in the village all year round and who usually gains the confidence of the villagers.[6] The participating households clearly understand that such data are used for research purposes only.[7]

[3] This survey covered the six villages in Andhra Pradesh and Maharashtra. Its findings are reported in Jodha (1981).

[4] I compiled these rules from the investigator's worksheets of a supplementary tenancy schedule that were made available to me by N. S. Jodha, who supervised the collection of this schedule and reported its findings (Jodha 1981). His table 6 gives a quantitative summary of sharing rules of two general categories: inputs and outputs.

[5] See Jodha (1981) for more details on the duration of the contract.

[6] Figures on the extent of tenancy usually increase as the same team pursues data collection over time. This is true of the VLS data. See also Bliss and Stern (1982).

[7] Some sampled households are usually given a trip to the headquarters of ICRISAT, where the purposes of the institution are explained to the participants.

III. Empirical Analysis

It has been noted in the previous section that most tenants are mixed in the sense of cultivating some land they own. The comparison of a family's average inputs and outputs per unit area on land that is owned and land that is sharecropped was first proposed by Bell (1977) in testing between the implications of the monitoring and the Marshallian approaches to sharecropping. Such a test holds constant family-specific characteristics, such as management, access to non-traded inputs, and prices of traded inputs and outputs. Thus the comparison of average input intensities on owned and sharecropped lands of the same household is the appropriate method of testing between the two modeling approaches to sharecropping.

I now study a framework to set the stage for testing between the two approaches. It is assumed that the landlord chooses the size of the rented area, t, and the sharecropper's share, α. The cost-sharing rules are described in the previous section; for simplicity of exposition, I assume that sharecroppers bear the full cost of all variable inputs.

The situation of mixed owner-tenants is analyzed in Shaban (1985), where it is shown that, if the tenants choose the labor input, the landlord will not be able to devise a contract that equates the marginal products of labor on owned and sharecropped land, provided the elasticity of substitution is different from zero.

In the case of many inputs, let the relation between output and the n variable inputs and land be summarized by a well-behaved production function of land and n variable inputs: $Y = F(X_1, X_2, \ldots, X_n, t)$. Denote output price by P and the family's shadow cost of each unit of the jth input by p_j. Let the superscript o stand for variables on own plots and s stand for variables on sharecropped plots.

Then if the mixed owner-sharecropper chooses the levels of variable inputs, $\mathbf{X} = (X_1, X_2, \ldots, X_n)$, the appropriate Marshallian marginal conditions of the farmer's behavior are[8]

$$\alpha P \frac{\partial F}{\partial X_i}(\mathbf{X}^s, t^s) = p_i = P \frac{\partial F}{\partial X_i}(\mathbf{X}^o, t^o), \quad i = 1, \ldots, n. \tag{1}$$

If the landlord stipulates and effectively monitors the sharecropper's activities, the appropriate marginal conditions of the farmer's behavior are

$$P \frac{\partial F}{\partial X_i}(\mathbf{X}^s, t^s) = p_i = P \frac{\partial F}{\partial X_i}(\mathbf{X}^o, t^o), \quad i = 1, \ldots, n. \tag{2}$$

[8] The objective function of the farmer can be either net revenues or a utility function defined over income and leisure. An interior solution is assumed. If the tenant's share of a given input's cost is α, then the marginal conditions for this input's allocation are identical under the Marshallian and monitoring approaches.

The construction of a test of the validity of equation (1) or (2) in characterizing the behavior of mixed sharecroppers rests heavily on the following proposition.

PROPOSITION. If the production function $F(\mathbf{X}, t)$ is linearly homogeneous in all inputs $(\mathbf{X}, t)$ and the variable inputs $(\mathbf{X})$ are normal, then equation (1) implies

$$\frac{X_i^s}{t^s} < \frac{X_i^o}{t^o}, \quad \text{for all } i = 1, \ldots, n. \tag{3}$$

Proof. See Shaban (1985).

Remark.—Linear homogeneity, or homotheticity in general, in a set of inputs implies that such a set consists of normal inputs. However, if a subset is held fixed, the remaining variable inputs are not necessarily normal.[9] Thus the assumption of normality of the variable inputs is needed in addition to the assumption of linear homogeneity in all inputs.

The importance of the proposition above is that it allows a powerful and robust test between the competing modeling approaches to sharecropping.[10] On the basis of equations (1) and (2), the monitoring approach would predict equal input intensities on owned and sharecropped land, while the Marshallian approach would predict higher input intensities per unit area on owned relative to sharecropped land. Such a test is robust with respect to the specification of the form of the production function since it places general restrictions on it, restrictions that are satisfied, for example, by the commonly applied Cobb-Douglas, constant elasticity of substitution, and constant ratio elasticity of substitution–homothetic production functions. Furthermore, while normality is a necessary assumption for the test in the next section, linear homogeneity is only sufficient for that test.[11] A

[9] For the definition of input normality, see Bear (1965) and Ferguson (1968). The proof of the remark consists in constructing a constant returns to scale production function $F(\mathbf{Z}, r)$ from the strictly concave and monotonic function $f(\mathbf{Z})$, where $\mathbf{Z}$ is a vector of variable inputs and r is a positive fixed factor of production. This is accomplished by defining $F(\mathbf{Z}, r) = rf(\mathbf{Z}/r)$; F is monotonic in all its arguments and constant returns to scale in $(\mathbf{Z}, r)$, and one can show that the production frontier defined by F is a cone. Notice that some of the $\mathbf{Z}$ elements could be inferior with respect to the production function f, but they have to be normal with respect to the production function F.

[10] A possible alternative test that has been suggested by Mark Schankerman and James Heckman would be based on comparing the input/output ratios of the owned and sharecropped lands of the same household. However, the test in this paper, which is based on input/land and output/land ratios, has two advantages. First, its results are simple to interpret. Second, the results are easily comparable with those of previous studies that are based on a similar notion; see Sec. IV.

[11] Linear homogeneity is not a necessary condition for the test carried out in the paper. Equations (4) and (5) can also be derived from input demand equations that are derived from a nonhomogeneous production function as long as the dummy variables and error terms interact with the plot area.

test for normality of the inputs in this sample is generally supportive.[12] Because comparisons are made on the owned and sharecropped land of the same household, there is no need for input and output price data, which are usually aggregated to an undesirable extent. More important, the comparison of average input intensities does not require any assumption about such unobserved variables as the shadow wage rates of family labor.[13]

A. *The Estimated Equation*

Let a mixed owner-sharecropper cultivate K owned and L sharecropped plots. There are n variable inputs. Input intensities per unit area on the owned and sharecropped plots are given by

$$x_{ik}^{o} = g_i(\mathbf{Z}) + \sum_{m=1}^{M} \beta_{mi} D_{mk} + \sum_{j=1}^{J} \gamma_{ji} E_j + \epsilon_i, \quad k = 1, \ldots, K, \tag{4}$$

$$x_{il}^{s} = g_i(\mathbf{Z}) + \sum_{m=1}^{M} \beta_{mi} D_{ml} + \sum_{j=1}^{J} \gamma'_{ji} E_j + \eta_i, \quad l = 1, \ldots, L, \tag{5}$$

where household subscripts are dropped, and i denotes input i.

The term $g_i(\mathbf{Z})$ is a function of deterministic and stochastic variables that have identical effects on the choice of intensity of input i on owned and sharecropped plots; examples of these variables are 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. The terms D_{mk} and D_{ml} are plot-specific

[12] A normality test is carried out for the sample of mixed owner-sharecroppers (see Sec. III*B*1 below). Since price data are unavailable, I use a cost function approach and regress

$$x_i = \beta_1 y + \beta_2 y^2 + \sum_{j=1}^{37} \beta_{3j} D_{3j} + \sum_{j=1}^{J} \beta_{4j} D_{4j} + \epsilon_i, \quad i = 1, \ldots, 8,$$

where x_i = intensity of input i per unit area, y = output per area, D_{3j} are village-year dummy variables that reflect price variation as well as other variation across years and villages, and D_{4j} are plot-specific attributes such as irrigation, soil quality, plot value, and tenancy. Normality of inputs is satisfied if $\partial x_i/\partial y = \beta_1 + 2\beta_2 y > 0$. The terms β_1 and β_2 are positive for family female labor, fertilizer, and other inputs. For the remaining five inputs, $\beta_1 > 0$ and $\beta_2 < 0$, but the numbers of observations that violate normality are four for family male labor, zero for hired male labor, three for hired female labor, 28 for bullock labor, and 14 for seed; the total number of observations in this regression is 704. Thus we find normality to be a reasonable assumption.

[13] Several empirical studies on agriculture in less developed countries have assumed equality of the family's shadow wage rate with the observed average village-level wage rate (see, e.g., Barnum and Squire 1979). While this assumption simplifies empirical analysis, the implication of homogeneity of family and hired labor is unjustifiable in traditional agriculture (see Deolalikar and Vijverberg 1983).

variables such as plot value, soil quality (measured by several dummy variables), and a dummy variable to stand for whether the plot is irrigated or not. It is important to control for land quality because it varies across tenure status.[14] The E_j are household-specific attributes that are expected to have a differential impact on input intensities on owned and sharecropped plots. Dummy variables for villages will partially reflect the variation in the cost-sharing rules across these villages.[15]

The error terms in equations (4) and (5), ϵ_i and η_i, are supposed to capture the household's particular and unobserved characteristics that lead to differential behavior on its owned and sharecropped land and that are not captured by the intercept terms. These errors arise because of some variation in sharecropping contracts across households in the same village or because of some particular relation between a landlord and a tenant, a relation that varies across households. In short, the error terms are the missing variables that affect owned and sharecropped plots differentially. Thus the error term for a given input is assumed to be identical across all plots of the same tenure status for each household. The error terms are assumed to have zero means and finite variances; nonzero correlation between error terms of different inputs is permitted.

Equations (4) and (5) allow us to derive the difference in the weighted averages of input intensities on owned and sharecropped plots, where the weights are the plot areas, t:

$$\Delta x_i \equiv \frac{\sum_k x_{ki}^o t_k}{\sum_k t_k} - \frac{\sum_l x_{li}^s t_l}{\sum_l t_l} = \sum_m \beta_{mi}\left(\frac{\sum_k D_{mk} t_k}{\sum_k t_k} - \frac{\sum_l D_{ml} t_l}{\sum_l t_l}\right) + \sum_{j=1}^{J} (\gamma_{ji} - \gamma'_{ji})E_j + \epsilon_i - \eta_i. \tag{6}$$

Let

$$D_m^o \equiv \frac{\sum_k D_{mk} t_k}{\sum_k t_k},\; D_m^s \equiv \frac{\sum_l D_{ml} t_l}{\sum_l t_l},$$

[14] When the estimation allows the β_{mi} to differ across tenure status, such differences are statistically insignificant for soil quality dummy variables. They differ somewhat for the plot value and irrigation dummy variable, but other estimated coefficients and standard errors in the estimated equation are hardly affected.

[15] Dummy variables for years and the size class of operational holdings were included and found insignificant. A time trend was also included and found insignificantly different from zero, suggesting that differential behavior on owned and sharecropped land does not vary over the time period of the sample.

$\theta_{ji} \equiv \gamma_{ji} - \gamma'_{ji}$, and $\upsilon_i \equiv \epsilon_i - \eta_i$. The terms D^o_m and D^s_m are the weighted averages of the mth dummy variables on owned and sharecropped plots, respectively. The equation to be estimated is

$$\Delta x_i = \sum_m \beta_{mi}(D^o_m - D^s_m) + \sum_{j=1}^{J} \theta_{ji}E_j + \upsilon_i, \quad i = 1, \ldots, n. \tag{7}$$

The error term $\boldsymbol{\upsilon}$ has a zero mean and a finite variance-covariance matrix: $E(\boldsymbol{\upsilon}) = \mathbf{0}$, $E(\boldsymbol{\upsilon} \cdot \boldsymbol{\upsilon}') = \boldsymbol{\Omega}$, where $\boldsymbol{\Omega}$ is a positive definite n-dimensional matrix that is not necessarily diagonal. Under these assumptions, Zellner's method of estimating seemingly unrelated regressions is efficient.

Let $\bar{D}^o_m$ and $\bar{D}^s_m$ represent the sample averages of the weighted dummy variables D^o_m and D^s_m (on owned and sharecropped land, respectively). Also, $\bar{E}_j$ is the average value of E_j. Then equation (7) can be rewritten as

$$\begin{aligned}\Delta x_i = {} & \sum_m \beta_{mi}[(D^o_m - \bar{D}^o_m) - (D^s_m - \bar{D}^s_m)] + \beta_{1i}(\bar{D}^o_1 - \bar{D}^s_1) \\ & + \beta_{2i}(\bar{D}^o_2 - \bar{D}^s_2) + \sum_{m=3}^{M} \beta_{mi}(\bar{D}^o_m - \bar{D}^s_m) + \sum_{j=1}^{J} \theta_{ji}\bar{E}_j + \upsilon_i, \\ & i = 1, \ldots, n,\end{aligned} \tag{8}$$

where D_m is the dummy variable for irrigation when $m = 1$, the plot value when $m = 2$, and the dummy variable for soil quality when $m = 3, \ldots, M$. Notice that when soil, plot values, and irrigation quality are constant across tenure status, on average (i.e., $\bar{D}^o_m = \bar{D}^s_m$, for $m = 1, \ldots, M$), then $\Sigma^J_{j=1}\, \theta_{ji}E_j$ measures the pure tenancy contribution to the difference in input intensity Δx_i.

The mean difference in input intensity, $E(\Delta x_i)$, can then be decomposed into four sources, assuming that $E(\Delta x_i) \neq 0$:

$$\begin{aligned} 1 = {} & \frac{\beta_{1i}(\bar{D}^o_1 - \bar{D}^s_1)}{E(\Delta x_i)} + \frac{\beta_{2i}(\bar{D}^o_2 - \bar{D}^s_2)}{E(\Delta x_i)} \\ & + \frac{\sum_{m=3}^{M} \beta_{mi}(\bar{D}^o_m - \bar{D}^s_m)}{E(\Delta x_i)} + \frac{\sum_{j=1}^{J} \theta_{ji}\bar{E}_j}{E(\Delta x_i)} \\ \equiv {} & \xi_{1i} + \xi_{2i} + \xi_{3i} + \xi_{4i}, \quad i, \ldots, n, \end{aligned} \tag{9}$$

where ξ_{1i}, ξ_{2i}, ξ_{3i}, and ξ_{4i} are defined as the proportion of the mean difference $E(\Delta x_i)$ that can be attributed to irrigation, plot value, soil, and tenancy, respectively. Thus equation (9) provides a convenient decomposition of the sources of the mean difference in input and output intensities on owned and sharecropped land.

The estimation and testing procedure is the following. Equations (7) are estimated jointly for the differences in all inputs using Zellner's method of estimating seemingly unrelated regressions.[16] Then a test between the competing approaches to modeling sharecropping is carried out; this is based on the pure effect of tenancy, which is captured by the intercepts $[\theta_{ji}]$. The assumption of perfect monitoring of sharecroppers' activities is taken as the null hypothesis; it predicts that

$$H_0\colon \theta_{ji} = 0, \quad \text{for all } i = 1, \ldots, n; j = 1, \ldots, J.$$

The Marshallian productive inefficiency of sharecropping would prevail if the mixed sharecroppers supply more inputs per acre to their owned relative to sharecropped land:

$$H_A\colon \theta_{ji} > 0, \quad \text{for all } i = 1, \ldots, n; j = 1, \ldots, J.$$

A special case of this test occurs under the additional assumption of equal land quality across tenure status, that is, $D^o_m = D^s_m$, for each household and no variation in the vector of intercepts E_j. Then the estimation of equations (7) reduces to regressing the difference in input intensities, Δx_i, on an intercept. The monitoring approach would predict that such an intercept is zero while the Marshallian approach predicts a positive intercept. A one-tail t-test would then be carried out if we consider a single input or output, or an F-test based on Hotelling's T^2-statistic would be employed in the case of multiple inputs; the existing empirical literature has been limited to either of these two options.[17]

B. *Results*

1. Mixed Sharecroppers

Equations (7) are estimated jointly for the set of eight observable inputs and are estimated separately for total output; the results are reported in table 3. The vector of mean differences of the dependent variables is positive in all its components.[18] When Hotelling's T^2-statistic is used, the F-value of a test of the significance of this vector of differences is 14.1 with (8,344) degrees of freedom; this is significantly different from zero at the 0.01 percent level.

[16] Since the independent variables are identical across all equations, the parameter *estimates* are identical to those obtained from estimating the equations separately. However, the F-tests use the full variance-covariance matrix $\boldsymbol{\Omega}$ instead of its diagonal elements only.

[17] The special case of using Hotelling's T^2-statistic is represented by Bell (1977).

[18] The category of "other inputs" includes the value of pesticides, manure, and "machinery"; the last category covers mostly the cost of fuel for irrigation equipment.

However, the significance of the estimates of plot value and irrigation and soil quality dummy variables implies that part of these differences can be explained by land quality differences across tenure status. With these land quality differences held constant, the coefficients of the village dummy variables measure the pure effect of tenancy. Most of these coefficients are positive, and they are jointly significant at the 1 percent level for five villages and at the 5 percent level for a sixth village.[19] Most village dummy coefficients are positive and significantly so in the case of the family male, family female, and bullock labor. The costs of these three inputs are fully borne by sharecroppers in all villages, and they are of fundamental importance in traditional agriculture. The village dummy coefficients for other inputs are less significant and have more negative signs. Hired labor, seed, fertilizer, and other inputs are sometimes cost-shared with the landlord depending on the village and the input (see Sec. II). Variation in these cost-sharing rules can partially explain the variation in these coefficients; for example, seed, fertilizer, and other inputs are cost-shared with the landlord in Dokur, and their coefficients are singly insignificantly different from zero at the 1 percent level in that village.[20]

In table 3 ξ_1, ξ_2, ξ_3, and ξ_4 provide an estimate of the percentages of the mean difference in the dependent variable that can be accounted for by differences in irrigation, plot value, soil quality, and tenure status, respectively (see eq. [9]). Differences in irrigation between owned and sharecropped plots are more important than variation in soil quality or plot value in accounting for the mean difference in average input intensities. It is important to notice that, even after accounting for irrigation and soil quality differences, the differences in input and output intensities that are due to the sharecropping arrangement are quite sizable; this difference equals 16.3 percent of the output per acre on owned land. The percentage differences of input intensities due to sharecropping relative to input intensity on owned land equal 20.8 percent for family male labor, 46.7 percent for family female labor, 16.6 percent for bullock labor, 17.9 percent for seeds, and 12.4 percent and 14.5 percent for hired male and female labor. The use of fertilizers is less on owned plots by 10.4 percent.

I conclude that irrigation makes an important difference to the use

[19] Villages A and F contribute only four and 26 observations to the regression in table 3, respectively (see table 1).

[20] See n. 8. Furthermore, I conjecture that cost-sharing rules in villages G and H (which are not documented) favor sharecroppers relative to other villages. However, one should not attribute too much of the variation in these coefficients to differences in cost-sharing arrangements since the available cost-sharing data are neither complete nor sufficiently quantifiable.

TABLE 3

DIFFERENCES ON OWNED AND SHARECROPPED LAND OF OWNER-CUM-SHARECROPPERS (N = 352): ESTIMATION OF EQUATION (7)

Variable	Family Male Labor	Family Female Labor	Hired Male Labor	Hired Female Labor	Bullock Pair Labor	Seed	Fertilizer	Other Inputs	Total Output
A	46.6	−2.3	−4.4	−6.6	3.2	51.1	13.2	−39.5	516.0
	(35.6)	(30.0)	(25.3)	(56.8)	(12.1)	(29.3)	(29.7)	(86.2)	(226.2)
B**	20.3	1.2	28.2	15.3	14.2	−.9	−22.5	−13.5	−135.5
	(12.5)	(10.6)	(8.9)	(20.0)	(4.3)	(10.3)	(10.5)	(30.4)	(79.8)
C**	25.7	40.9	2.3	29.0	6.0	6.6	−9.1	12.8	138.9
	(8.5)	(7.2)	(6.0)	(13.6)	(2.9)	(7.0)	(7.1)	(20.6)	(54.0)
D*	10.0	10.7	2.1	16.8	7.1	9.8	−3.3	−4.4	29.6
	(7.7)	(6.5)	(5.5)	(12.4)	(2.6)	(6.4)	(6.5)	(18.7)	(49.2)
E**	10.1	17.7	14.9	25.9	10.8	3.7	18.1	17.3	264.5
	(11.5)	(9.7)	(8.2)	(18.4)	(3.9)	(9.5)	(9.6)	(27.9)	(73.2)
F	17.0	8.1	3.6	23.2	9.9	4.9	−2.2	18.4	143.8
	(13.7)	(11.5)	(9.7)	(21.8)	(4.6)	(11.2)	(11.4)	(33.1)	(86.9)
G**	22.6	43.7	−3.4	−9.5	4.9	−4.5	−10.1	60.4	110.8
	(9.9)	(8.3)	(7.0)	(15.7)	(3.4)	(8.1)	(8.2)	(23.9)	(62.7)
H**	22.5	−.04	−4.3	−23.5	−1.8	28.0	15.1	141.1	83.1
	(12.6)	(10.7)	(9.0)	(20.2)	(4.3)	(10.4)	(10.6)	(30.6)	(80.4)
Irrigated area**[a]	74.7	60.0	43.4	188.0	11.5	49.0	53.0	241.1	851.4
	(13.6)	(11.5)	(9.7)	(21.8)	(4.7)	(11.2)	(11.4)	(33.0)	(86.7)
Plot value**	.81	−.02	−.50	.27	.27	.19	1.2	.56	5.9
	(.33)	(.27)	(.23)	(.52)	(.11)	(.27)	(.27)	(.80)	(2.1)

Shallow soil**[b]	−37.5	−22.0	−18.0	−17.9	−7.3	28.0	−15.1	−22.2	−79.1
	(9.6)	(8.1)	(6.8)	(15.3)	(3.3)	(7.9)	(8.0)	(23.3)	(61.1)
Poor soil*	−13.9	−52.4	−16.5	−46.6	3.4	8.4	6.0	−10.0	−75.6
	(16.1)	(13.6)	(11.5)	(25.7)	(5.5)	(13.3)	(13.5)	(39.0)	(102.4)
Other soil**	−33.2	−29.2	−61.8	−76.4	−19.5	−13.1	−63.5	50.5	−350.9
	(26.5)	(22.4)	(18.9)	(42.4)	(9.0)	(21.9)	(22.2)	(64.3)	(168.8)
F-value	12.4	11.9	4.0	10.6	7.7	4.7	7.3	10.3	18.9
R^2	.32	.31	.13	.29	.23	.15	.22	.28	.42
Mean difference[c]	29.9	25.3	7.1	29.7	9.5	10.5	6.5	50.0	192.2
$\frac{E(\Delta x_i)}{E(x_i^o)}$ [d]	33.2	55.3	19.1	32.1	22.7	26.5	20.6	41.0	32.6
ξ_1[e]	22.7	21.5	55.7	57.4	11.0	42.5	73.5	43.8	40.2
ξ_2[f]	8.6	−.3	−22.6	2.9	9.2	5.8	59.4	3.5	9.7
ξ_3[g]	6.2	−5.7	1.9	−5.5	6.8	−16.0	17.9	2.7	.0
ξ_4[h]	62.5	84.5	64.9	45.1	73.0	67.7	−50.7	50.0	50.1
$\xi_4 \times \frac{E(\Delta x_i)}{E(x_i^o)}$	20.8	46.7	12.4	14.5	16.6	17.9	−10.4	20.5	16.3

NOTE.—Average difference across all households in input intensity per acre on owned minus sharecropped land. Human and bullock labor are measured in hours per acre; plot value is measured in 100 rupees per acre; other variables are measured in rupees per acre. Standard errors are in parentheses.

* Jointly significantly different from zero at the 5 percent significance level.

** Jointly significantly different from zero at the 1 percent significance level.

[a] The omitted category is "unirrigated area."

[b] The omitted category is "medium and deep soil."

[c] The mean difference of the dependent variable, $E(\Delta x_i)$.

[d] The percentage difference of input per acre on owned minus sharecropped land relative to the value of input per acre on owned land.

[e] The percentage of the mean difference that can be accounted for by irrigation (see eq. [9]); $\bar{D}_1^o - \bar{D}_1^s = .0908$.

[f] The percentage of the mean difference that can be accounted for by plot value; $\bar{D}_2^o - \bar{D}_2^s = 3.1844$.

[g] Same as n. e., but for soil; $\bar{D}_m^o - \bar{D}_m^s = -.0745$ for shallow soil, .0562 for poor soil, and .0046 for "other soil."

[h] Same as nn. e and f, but for the pure effect of tenancy (see eq. [9]).

of inputs. But when the effect of irrigation, plot value, and soil quality on input use is held constant, the pure effect of tenancy is to generate lower input (and output) intensities; this is particularly true for family and bullock labor, where the difference is sizable and statistically significant. With such evidence, the monitoring approach to sharecropping should be rejected.[21]

2. Owner-cum-Sharecroppers of Sorghum Only

One possible objection to the test in the previous section is that the sizable and significant difference in inputs and output per acre on owned and sharecropped plots may be due to the choice of the crop rather than input choice for a *particular* crop; mixed tenants could be growing different crops, requiring varying levels of inputs, on plots of different tenure status. If this is true, it would create an identification problem in general, but it would continue to provide a strong rejection of the monitoring approach since it would be difficult to argue that landlords can monitor input use more easily than crop choice. In any case, input use for a single crop will be analyzed in this section.

The most common crop in the semiarid villages in the sample is sorghum. In the sample there are 76 farmers who cultivate only sorghum (i.e., without intercropping) on plots that they own and others that they sharecrop. These farmers are mostly drawn from Shirapur and Kalman, where the cultivation of sorghum is more common than in other villages.

Table 4 gives the results of estimating the regressions in equations (7) and the decomposition of the differences in input intensities according to irrigation, plot value, soil quality, and tenure status.[22] The vector of intercept estimates is positive in seven out of its eight components and is significantly different from the zero vector at the 1 percent level. The intercepts are significantly positive at the 1 percent level for family male and bullock labor and for total output and are significantly positive at the 5 percent level for family female and hired male labor. The decomposition of the intensity differences shows that, while irrigation, plot value, and soil quality differences are held constant at their average values, output per acre is higher on the owned land relative to the sharecropped land by 27.6 percent; this

[21] By monitoring the output level and using the threat of eviction in a long-term contract, the landlord may force the sharecropper to provide the "productively efficient" level of inputs. This possibility is not rejected by the tests in this paper since the land-to-the-tiller legislation in the sampled villages results in short-term contracts that would dampen the effectiveness of any threat of eviction.

[22] Differences between the coefficients of the dummy variables of the villages Shirapur and Kalman are not significant and are thus replaced by a simple intercept.

TABLE 4

REGRESSION AND DECOMPOSITION OF INPUT AND OUTPUT DIFFERENCES ON OWNED MINUS SHARECROPPED LAND FOR MIXED SHARECROPPERS: SOLE SORGHUM PLOTS (N = 76)

Variable	Family Male Labor	Family Female Labor	Hired Male Labor	Hired Female Labor	Bullock Pair Labor	Seed	Fertilizer	Other Inputs	Total Output
Intercept*	12.4	3.9	4.0	.1	4.5	−.3	.8	2.5	74.8
	(3.1)	(1.7)	(2.0)	(2.2)	(1.4)	(.3)	(1.1)	(2.6)	(25.1)
Irrigated area*	35.8	17.1	10.5	28.0	18.1	3.8	15.8	71.8	29.2
	(11.2)	(6.1)	(7.0)	(8.0)	(4.9)	(1.2)	(3.8)	(9.2)	(89.9)
Plot value	.61	−.12	−.14	.17	.05	.09	−.15	.38	−.35
	(.41)	(.22)	(.26)	(.29)	(.18)	(.05)	(.14)	(.34)	(3.3)
Shallow soil	−6.8	−.6	.4	−6.2	−2.6	.8	−1.4	.8	−31.9
	(6.3)	(3.4)	(4.0)	(4.5)	(2.7)	(.7)	(2.2)	(5.2)	(50.5)
Poor soil	6.4	5.3	4.6	.7	6.4	1.4	−1.0	−.6	−14.3
	(8.9)	(4.8)	(5.6)	(6.3)	(3.9)	(1.0)	(3.0)	(7.3)	(71.1)
F-value	4.3	2.3	.8	4.0	4.6	4.5	4.3	18.1	1.8
R^2	.19	.11	.04	.19	.20	.20	.20	.51	.09
Mean difference	14.9	5.2	4.9	1.4	6.1	.0	1.1	4.5	80.8
$\frac{E(\Delta x_i)}{E(x_i^o)}$[a]	38.2	43.8	20.4	6.4	22.7	...	100.0	62.6	29.8
ξ_1[b]	6.9	9.5	6.2	57.5	8.5	...	41.5	46.2	8.2
ξ_2[c]	.8	−.5	−.6	2.4	.2	...	2.6	1.7	−.1
ξ_3[d]	8.9	16.2	13.7	30.9	18.1	...	7.1	−3.0	−.7
ξ_4[e]	83.3	74.8	80.7	9.2	73.3	...	68.2	55.1	92.6
$\xi_4 \times \frac{E(\Delta x_i)}{E(x_i)}$	31.8	32.8	16.5	.5	16.6	...	68.2	34.5	27.6

NOTE.—The average difference across all households in input intensity per acre on owned minus sharecropped land. Human and bullock labor are measured in hours per acre; plot value is measured in 100 rupees per acre; other variables are measured in rupees per acre. Standard errors are in parentheses.

* Jointly significantly different from zero at the 1 percent significance level.

[a] The percentage difference of input per acre on owned minus sharecropped land relative to the value of input per acre on owned land.

[b] The percentage of the mean difference that can be accounted for by irrigation (see eq. [9]); $\bar{D}_1^o - \bar{D}_1^s$ = .02885.

[c] Same as n. b., but for plot value; $\bar{D}_2^o - \bar{D}_2^s$ = .1945.

[d] Same as n. b., but for soil; $\bar{D}_m^o - \bar{D}_m^s$ = −.0513 for shallow soil and .152 for poor soil.

[e] Same as n. b., but for the pure effect of tenancy (see eq. [9]).

percentage difference is 31.8 percent, 32.8 percent, and 16.6 percent for family male, family female, and bullock labor, respectively.

3. Owner-cum-Tenants

One may argue that the differential behavior of mixed owner-sharecroppers on their owned and rented land is an outcome of tenancy per se. Two examples illustrate such an argument. First, if investment and current inputs are complements, the short duration of the rental contracts implies a lower incentive to invest and, consequently, a lower level of current inputs on the rented land. Second, if the rented land is further away from a farmer's house than his own land, then he may find it more costly to spend his resources on the rented land. If this line of reasoning is valid for the current sample, we should find that mixed tenants, who lease land on a fixed-rent basis, treat the owned and rented land differently. But this is not the case.

In the sample there are 90 mixed tenants who lease land on a fixed-rent basis. The findings indicate that no systematic difference exists between the application of inputs to owned and rented land of these mixed tenants. Thus the contractual arrangement of sharecropping is the element responsible for the resource allocation observed in the previous two sections.

The regressions and decomposition of the mixed fixed-rent tenants are presented in table 5. First, notice that these gross differences in average intensities are relatively small and have no systematic pattern. Input intensity differences are positive in the case of family male and female labor, hired female labor, seed, other inputs, and total output, but they are negative for hired male labor, bullock labor, and fertilizer. The intercept term gives the pure tenancy effect when irrigation, plot value, and soil quality differences are taken into account; this intercept is positive for four inputs and negative for the other four. More important, this intercept is *not* significantly different from zero (at the 5 percent level) for seven out of the eight inputs and for total output. Thus we cannot reject the null hypothesis of identical input and output intensities on plots that are owned and those that are rented on a fixed-rent basis, after taking irrigation, plot value, and soil quality into account.

IV. The Existing Empirical Evidence

The question posed in various empirical studies on tenancy is whether the observable magnitudes of inputs and outputs differ systematically between sharecropped land on the one hand and land that is owned

TABLE 5

REGRESSION AND DECOMPOSITION OF INPUT AND OUTPUT DIFFERENCES ON OWNED MINUS RENTED LAND FOR MIXED AND FIXED-RENT TENANTS (N = 90)

Variable	Family Male Labor	Family Female Labor	Hired Male Labor	Hired Female Labor	Bullock Pair Labor	Seed	Fertilizer	Other Inputs	Total Output
Intercept	1.5	4.5	−1.8	−1.7	−1.1	10.7	−5.9	18.3	29.9
	(6.9)	(5.7)	(5.1)	(4.6)	(3.2)	(3.6)	(6.0)	(17.6)	(51.5)
Irrigated area*	115.1	11.0	53.8	54.6	21.3	20.2	59.2	273.6	811.7
	(25.4)	(20.7)	(18.8)	(16.7)	(11.7)	(13.11)	(21.9)	(64.4)	(188.2)
Plot value	−.33	−.60	.33	.80	.01	.10	.45	−.29	6.2
	(.65)	(.53)	(.48)	(.43)	(.30)	(.34)	(.56)	(1.6)	(4.8)
Shallow soil	6.1	19.1	−46.8	10.4	−25.4	2.2	−23.2	68.2	29.1
	(24.9)	(20.3)	(18.4)	(16.4)	(11.5)	(12.9)	(21.5)	(63.1)	(184.8)
Poor soil*	18.9	79.3	−85.9	−14.7	−97.0	9.4	18.7	258.5	429.1
	(49.7)	(40.5)	(36.7)	(32.7)	(23.0)	(25.7)	(42.8)	(126.0)	(368.5)
Other soil	−13.8	15.7	−22.4	−5.7	−27.6	−4.2	22.0	179.1	157.4
	(26.6)	(21.6)	(19.6)	(17.4)	(12.3)	(13.7)	(22.9)	(67.2)	(196.7)
F-value	4.5	1.5	5.9	4.6	6.0	.6	4.1	7.7	6.4
R^2	.21	.08	.26	.21	.26	.03	.20	.31	.28
Mean difference	3.0	4.6	−2.8	1.5	−2.5	11.4	−4.6	29.2	64.1
$\frac{E(\Delta x_i)}{E(x_i^o)}$ [a]	4.6	13.1	−6.4	2.7	−6.5	26.1	−15.2	33.3	12.3
ξ_1 [b]	71.0	4.5	−36.2	66.2	−15.8	3.3	−24.3	17.6	23.7
ξ_2 [c]	−24.8	−30.0	−27.4	120.2	−.5	2.0	−22.6	2.3	22.3
ξ_3 [d]	5.0	28.8	99.3	24.3	73.2	.7	6.6	21.9	7.4
ξ_4 [e]	48.8	96.7	64.3	−110.7	43.1	94.0	130.3	62.8	46.6
$\xi_4 \times \frac{E(\Delta x_i)}{E(x_i)}$	2.2	12.7	−4.1	−3.0	−2.8	24.5	−19.8	20.9	5.7

NOTE.—The average difference across all households in input intensity per acre on owned minus rented land. Human and bullock labor are measured in hours per acre; plot value is measured in 100 rupees per acre; other variables are measured in rupees per acre. Standard errors are in parentheses.

* Jointly significantly different from zero at the 1 percent significance level.

[a] The percentage difference of input per acre on owned minus rented land relative to the value of input per acre on owned land.

[b] The percentage of the mean difference that can be accounted for by irrigation (see eq. [9]); $\bar{D}_1^o - \bar{D}_1^s$ = .0187.

[c] Same as n. b., but for plot value; $\bar{D}_2^o - \bar{D}_2^s$ = 2.3125.

[d] Same as n. b., but for soil; $\bar{D}_m^o - \bar{D}_m^s$ = .0476 for shallow soil, .0027 for poor soil, and .0138 for "other soil."

[e] Same as n. b., but for the pure effect of tenancy (see eq. [9]).

or rented on fixed-rent terms on the other. The method chosen to answer such a question is to compare intensities of inputs or outputs per unit area on lands that are under different tenure status.[23]

With this approach, the existing evidence seems to be mixed. The studies that conclude that the behavior of sharecroppers is basically not different from that of owners include (*a*) Rao (1971) with evidence from Andhra Pradesh in India, (*b*) Chakravarty and Rudra (1973) with evidence from five Indian districts, (*c*) Dwivedi and Rudra (1973) with data from West Bengal in India, (*d*) Huang (1975) with Malaysian data, and (*e*) Nabi (1986) with survey data from Pakistan. On the other hand, the following studies have supported the Marshallian proposition of higher input and output intensities per unit area on owned relative to sharecropped land: (*a*) Zaman (1973) with data from Bangladesh, (*b*) Bell (1977) with data from Bihar in India, and (*c*) Chattopadhyay (1979) with a sample survey from West Bengal in India. In addition, Hossain (1977), using a sample survey from Bangladesh, and Bliss and Stern (1982), in their intensive study of Palanpur in India, have reported several tests, some of which support the Marshallian approach and others that are in support of the monitoring approach.

There are serious shortcomings in the existing empirical literature, and four of the major problems are identified below. Note that the test employed in Section III of this paper does not suffer from these problems.

A. *The Empirical Context of the Study*

In my thesis (Shaban 1985), and under the assumption of ineffective monitoring of the sharecropper's activities, I have shown that whether different characteristics can be observed between lands under sharecropping and those under fixed-rent tenancy critically depends on the presence of rent restrictions and the opportunities available to tenants. In particular, sharecropping and fixed-rent arrangements are shown to generate identical outcomes, in terms of incomes, labor/land, and output/land ratios, in the context of no alternative employment opportunities for the pure tenant and where a minimum subsistence income must be provided to the tenant as a participation constraint.[24] The same conclusion can also be derived

[23] No justification or statement of the assumptions that underlie such a method has been stated in the literature.

[24] Moreover, Shaban (1985) shows that with rent restrictions this context generates higher labor/land and output/land ratios under sharecropping compared with fixed-rent tenancy.

when the landlord stipulates and effectively monitors the sharecroppers' activities.

It follows, therefore, that a test based on data drawn from villages with subsistence agriculture and no effective alternative employment opportunities for pure tenants cannot discriminate between the competing modeling approaches to sharecropping.[25] For example, Huang (1975) found that sharecroppers are slightly more productive than owners or fixed-rent tenants in the state of Kelantan in Malaysia; he carefully characterized agriculture in that state as providing "limited income opportunities" and that farmers have difficulties in meeting their "subsistence needs" (pp. 707–8). Thus his findings are consistent with both the Marshallian and monitoring approaches and cannot be used as a discriminating test.[26]

B. *Separating Sharecroppers from Fixed-Rent Tenants*

The studies that use the Indian Farm Management Survey data (Chakravarty and Rudra 1973; Dwivedi and Rudra 1973) suffer because the published surveys lump all types of tenants together: the behavior of fixed-rent tenants is not distinguished from that of sharecroppers. While these studies have presumably chosen districts that have sharecropping as a predominant contractual arrangement, their conclusions should nonetheless be discounted if we are interested in the comparative behavior of different tenancy arrangements.

C. *Separating Sharecroppers from Owners*

The distinction between "tenants" and "owners" is quite problematic and arbitrary in the studies that use the Indian Farm Management Survey and in the studies of Zaman (1973) and Hossain (1977).[27] For example, Rao (1971, p. 588) defined "all those who lease in area—part as well as pure tenants—as tenants."[28] Aside from the uncom-

[25] This is not the case if tenants are mixed, i.e., they own some land of their own, as is shown in Shaban (1985).

[26] The studies that have paid attention to the tenant's alternative use of his labor time are Dwivedi and Rudra (1973), Huang (1975), Bell (1977), Hossain (1977), Bliss and Stern (1982), and Nabi (1986).

[27] It is not clear whether "tenants" in the studies by Chattopadhyay (1979) and Nabi (1986) include mixed as well as pure tenants.

[28] Chakravarty and Rudra (1973, p. 1239) chose to define as owners those "farmers who are owners of at least 50 per cent of the land cultivated by them" and the tenants as those "who cultivate land 50 per cent or more of which is leased in from others." Dwivedi and Rudra (1973) addressed the problem differently when they defined a "continuous variable" to stand for the extent of tenancy; the value of this variable equals the area leased for cultivation by a given farmer divided by his net cultivated

fortable arbitrariness in distinguishing tenants from owners in the case of mixed tenants, I provide a highly simplified example to show that there is no satisfactory discrete or continuous method of stratifying mixed owner-sharecroppers into "owners" and "sharecroppers."

Let the operational holding area of each mixed farmer be one unit, τ of which is owned and $(1 - \tau)$ is sharecropped. Let total family labor supply be inelastic and equal to one unit. It follows, then, that the labor/land ratio at the farm level equals one unit and is independent of τ! Furthermore, suppose that output as a function of labor (X) and land (t) is summarized by a well-behaved production function $F(X, t)$. Denote the sharecropper's share by α. Then under the hypothesis of ineffective monitoring of the tenant's labor, the farmer's problem is to allocate his labor to his own and the rented land:

$$\max_{0 \leq X \leq 1} Y = F(X, \tau) + \alpha F(1 - X, 1 - \tau). \tag{10}$$

Let starred values represent the optimized values of the variables. Then, with the envelope theorem, the Marshallian analysis would state that

$$\frac{\partial Y^*}{\partial \tau} = F_2(X^*, \tau) - \alpha F_2(1 - X^*, 1 - \tau) \gtreqless 0. \tag{11}$$

The validity of the studies that arbitrarily stratify mixed owner-sharecroppers into "owners" and "sharecroppers," when comparing the yield per unit area on different farms, critically depends on the derivative defined by equation (11) being positive for all values of τ between zero and one. This is not generally the case, however. In particular, it is straightforward to show that output per acre (Y^*) rises in τ and then falls if the production function is separable and the limit of the marginal product of land is "sufficiently high" as the plot size approaches zero. It is not difficult to generate data that are consistent with the Marshallian specification of labor allocation and at the same time would justify the conclusions of these studies that "owners" and "sharecroppers" have similar inputs and outputs per unit area.

D. *The Statistical Test*

In testing whether inputs and outputs per unit area differ between two populations (of owners and sharecroppers), some studies have

area. Correlation of this variable with inputs and outputs per unit area was then analyzed and tested for significance. Zaman (1973) is not explicit in his definition of tenants, but he seems to have followed Rao's definition. Hossain (1977) chose yet another definition of a tenant: a person who leases more than 25 percent of his operational holding area.

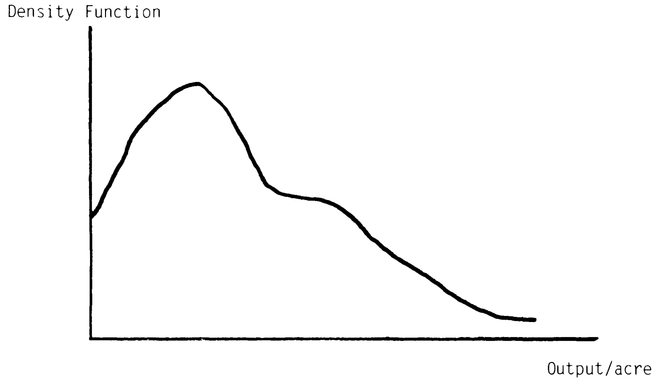

FIG. 1.—Density function of a typical distribution of output per acre

assumed that these populations are normally distributed (Dwivedi and Rudra 1973; Hossain 1977; Bliss and Stern 1982; Nabi 1986); the means of both populations are compared using the *t*-statistic. While the *t*-statistic generally provides a robust test with respect to some deviation from normality, the underlying distribution can hardly be considered normal. Figure 1 displays a distribution of output per acre for the data set used here. In the univariate mean comparison of two populations of unequal sizes, it would have been more appropriate to use a nonparametric test or a test based on a distribution that roughly approximates the data. This would certainly have changed the levels of significance of some tests and, in principle, may even reverse the conclusions of Dwivedi and Rudra (1973, p. 1293) and Nabi (1986, p. 437).

Some of the more careful studies, in particular Bell (1977)[29] and Bliss and Stern (1982), suffer from data limitations. The samples are small and do not contain data on important factors of production such as family and bullock labor. None of the existing studies has satisfactorily accounted for variations in soil quality and irrigation across land of different tenure status.[30]

In view of the discussion above, there is clearly a need for further empirical tests between the competing approaches to modeling agricultural tenancy. The analysis in this paper avoids the pitfalls of the existing literature, and it aims to fill a gap in this literature.

[29] However, Bell takes a narrow view of the Marshallian approach in his hypotheses 2–4. There is no reason to assume that endogenous share contract determination and the variation across soil conditions are inconsistent with the Marshallian analysis (see Shaban 1985).

[30] Needless to say, once the pitfalls of existing empirical evidence are avoided, conclusions based on other data sets may or may not support the conclusions of this study. More research with other data sets is still needed.

V. Conclusion

The existing theoretical literature on agricultural tenancy follows two basic approaches in modeling the outcome of agricultural contracts. The Marshallian approach assumes a prohibitively high cost of monitoring the tenant's activities, while the monitoring approach assumes that the landlord can monitor the tenant's activities effectively and inexpensively. The existing empirical evidence is inconclusive in judging the validity of either approach, and it has some serious shortcomings. The need for further empirical tests is obvious.

I presented new evidence using a rich and detailed data set collected by ICRISAT from eight villages in the semiarid tropical parts of India. The fact that most tenants own some land of their own provided a controlled environment; I analyzed the differences between input and output intensities per unit area on owned and leased plots of the same household. These differences were found to be sizable and significant for mixed sharecroppers. They can be decomposed into four sources: differential irrigation pattern on owned and leased land, plot value differences, differential soil quality, and an effect that can be attributed to the contractual arrangement.

The main empirical findings of the current study are the following: (1) Output and input intensities per acre are higher on the owned plots of a mixed sharecropper compared with the sharecropped plots. The percentage difference is 32.6 percent for output and ranges between 19 and 55 percent for the major inputs. (2) Differences in irrigation across tenure status are important in explaining a large fraction of the input and output differences; soil quality variations are not important. On average, with the variations in irrigation, plot value, and soil quality held constant, output per acre is higher by 16.3 percent on owned relative to sharecropped plots; similar percentages for inputs are 20.8 percent, 46.7 percent, and 16.6 percent for family male, family female, and bullock labor, respectively. These differences are statistically significant, suggesting a strong rejection of the monitoring approach to sharecropping. (3) Differences in input and output intensities between owned and sharecropped plots are also large and significant when we consider the plots of mixed sharecroppers on which only one crop (sorghum) is grown. (4) When the variation in irrigation, plot value, and soil quality is controlled for, no systematic or significant difference between the plots that are owned and those rented on a fixed-rent basis can be detected. Thus the sizable differences that are found in the case of sharecroppers are caused by the form of contractual arrangement and not tenancy per se.

Appendix

Selectivity Bias

Would pure sharecroppers treat their rented land differently than the mixed owner-sharecroppers? If so, the results for mixed sharecroppers (in Sec. III*B*) would suffer from selectivity bias if one were to interpret them as applicable to all sharecropped land. Nonetheless, such results would still be inconsistent with the monitoring approach because this approach would have to argue that the mixed sharecroppers treat their owned and rented land identically.

However, if pure and mixed sharecroppers treat the rented land similarly, the problem of selectivity bias does not arise. I tested for the existence of selectivity bias using three methods: Heckman's (1979) probit, Olsen's (1980) ordinary least squares method, and Lee's (1983) logit-type corrections. Additional data on potential selection variables are available for 349 mixed owner-sharecroppers and 70 pure sharecroppers. Table A1 gives the parameter estimates using the selection equation for the three methods of correction.

TABLE A1

VARIOUS ESTIMATES OF THE SELECTIVITY EQUATION

Independent Variables	Linear Probability	Probit	Logit
Intercept	...	...	18.01
A	.68	1.71	−13.91
B	.82	11.90	5.53
C	.70	5.31	−7.23
D	.84	3.66	−10.33
E	.74	3.85	−10.31
F	.83	6.31	−5.43
G	.86	16.67	13.84
H	.88	9.99	...
Irrigation	.12	9.29	17.80
Plot value	.01	.26	.47
Shallow soil	.26	4.35	8.24
Poor soil	.37	4.97	9.17
Other soil	.26	17.21	30.76
Value of farm equipment*	6.2	−.0002	−.0003
Value of house*	−1.7	.0002	.0003
Value of animal stock*	.02	.0006	.001
Small farmer	.12	2.40	4.41
Medium farmer	.13	1.44	3.09
Number of males aged 15–65	.032	1.05	1.99
Number of females aged 15–65	−.003	−.64	−1.29
Number of household dependents	.0004	−.26	−.47
Age of household head	−.0009	.0006	−.003
Sex of household head (= 1 if female)	.294	−4.53	−8.58
Education of household head	−.0026	−1.38	−2.81

NOTE.—1 = mixed owner-sharecropper, 0 = pure sharecropper.
* Measured in millions of rupees.

Equations (7) were reestimated with the selection variable as an additional explanatory variable. For the three methods of selectivity correction, the additional selection variable is insignificantly different from zero (at the 5 percent level) in every input and output difference equation. Thus we can conclude that selectivity bias is not present in the estimates. However, theoretical reasons prevent us from drawing too strong a conclusion from the absence of selectivity bias; a proper analysis of pure sharecroppers requires additional and more detailed knowledge of their alternative opportunities of employment (see Shaban 1985, chap. 2).

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