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SIZE, SUPERVISION, AND PATTERNS OF LABOR TRANSACTIONS

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A key insight of the modern economics of organization is that factors of production do not automatically get converted into outputs (as the conventional neoclassical treatment of firms or farms presumes), but that the nature of organization plays a critical role in determining the input-output-labor choices. Furthermore, the precise nature of organization itself is affected by the economic environment and it is determined contemporaneously with other choices that individuals make.[1]

This paper focuses on the role of supervision in agricultural production and labor transactions. It has been widely recognized that the own labor of a farmer (farm owner or operator) is potentially different from that of hired labor even when there is no significant difference in their skills, and that the productivity of hired labor depends, in part, on the extent of supervision and management provided by the farmer. This is because the labor hired on wages has not only a possible incentive to shirk; he (or she) also does not have the same level of commitment as the farmer to apply his labor in the most productive manner.

Under the above hypothesis, the market wage faced by a farmer does not entirely determine the return from his labor, because the return depends in part on how valuable his labor is on his own farm. The latter, in turn, is affected not only by the farmer's choice of inputs and hired labor, but also by his farm size. Clearly, therefore, the extent to which different farmers choose to work on their own farms is affected by the economic value of supervision, which in itself is endogenous.

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1. See Williamson (1985) for a recent overview.

This paper develops and analyzes a model in which the choice of supervision (that is, how much to supervise and manage) is determined simultaneously with farmers' other choices, such as family labor supply (on farm and outside farm), inputs and outputs. The most noteworthy aspect of this model is that it predicts patterns of behavior, across different farm sizes, which are strikingly different than those which would arise if supervision had no economic role to play.

Our model also has implications for empirical studies as well as for policy analysis. An obvious consequence of the interaction between own and hired labor is that, in an empirical analysis of farm households, it is unsatisfactory to treat a farmer's production decisions to be separable from his consumption-leisure decisions.[2] Also, a recognition of the supervision effect requires modifications in the analysis of labor demand and supply; we show, for instance, that the determinants of a farmer's labor demand are quite different depending on whether he supplies labor to the market or not. We also point out how supervision effects influence the land rent on farms of different sizes; this has implications not only for determining farmers' real incomes, but also for policies aimed at land reform and land redistribution.

1. The Model

In this section, we derive the conditions which characterize the economic choices of a farmer. These conditions, as we shall see in the next section, provide a basis for examining the patterns of behavior across farmers with different characteristics.

The production technology is assumed to be linearly homogenous. The output per unit of land, y, can thus be expressed as

$$(1) \quad y = y(\ell, x)$$

where ℓ is the *effective labor* input (that is, labor in efficiency units) per unit of land, and x is the vector of nonlabor inputs per unit of

2. Deolalikar and Vijverberg (1983) estimate the aggregate Cobb-Douglas production function to test the heterogeneity between hired and own labor. Subject to the well-known fundamental limitations in estimating direct production functions, they find own labor to be more productive than hired labor. Unlike the present paper, however, they do not address the issue of how farmers' choices are determined under or are affected by the heterogeneity between the two types of labor.

land.[3] The quantity of effective labor depends on how the farmer's own (family) labor hours are combined with the hired labor hours on the farm. If f and h respectively denote own labor hours and hired labor hours per unit of land, then ℓ is expressed as[4]

$$(2) \qquad \ell = \ell\,(f,\, h)$$

where ℓ is concave and increasing in its arguments. If supervision had no role to play, then (2) would be: $\ell = f + h$ In the presence of the supervision effect, on the other hand, it is natural to assume that an extra unit of own labor hour adds more to the effective labor input than what an extra unit of hired labor hour does. This is because the farmer can do whatever a hired worker can do; in addition, the farmer can supervise and manage. This assumption is expressed as

$$(3) \qquad \ell_f > \ell_h > 0$$

where a subscript denotes, throughout the paper, the variable with respect to which a partial derivative is being taken. Also note that, in expression (2), we have assumed that the effective labor is linearly homogeneous in its arguments; this assumption is made solely for simplicity. A more general analysis is easily possible.

The time endowment of a farmer is T hours, and his land area under operation is denoted by $A > 0$. A farmer's allocation of his time entails: (i) consumption as leisure, T hours; (ii) work on his own farm, Af hours; and (iii) hiring himself out in the market, M hours. The consumption of leisure, thus, can be expressed as

$$(4) \qquad T = \bar{T} - Af - M.$$

The farm income per unit of land is $py - w^h h - qx$, where p is the price of output, w^h is the wage rate for the hired worker, and q is the vector of prices of inputs. Correspondingly, the total income of a farmer with land area A is

3. Our analysis does not change if there are multiple outputs.

4. It should be apparent that expression (2) is not the only way to represent effective labor. An alternative for instance is to disaggregate own labor hours into hours spent on working on farm without supervising and hours spent on supervision. If s denotes hours spent solely on supervision per unit land, than ℓ can be expressed as: $\ell = (f - s) + \phi\,(s, h)$, where ϕ aggregates the supervision hours and hired labor hours into units of effective labor.

(5) $I = A[py - w^h h - qx] + w^M M$

where w^M is the wage rate at which the farmer can hire himself out. Using (4) and (5), the direct utility function of the farmer is defined, over leisure and income, as follows

(6) $U = U(T, I)$

The farmer takes the parameters $(A, \bar{T}, p, q, w^h, w^M)$ as given, and adjusts the control variables (f, M, h, x) to maximize his utility (6). The indirect utility level of the farmer can therefore be expressed as

(7) $V = \underset{f, M, h, x}{\text{Max:}}\ U(\bar{T} - Af - M, A[py(\ell(f, h), x) - w^h h - qx] + w^M M).$

The above maximization problem can be viewed, conceptually, as consisting of two parts. First, the profit per unit of land is maximized, given a parameterically specified amount of own labor per unit of land. This maximization can be expressd as the following conditional profit function

(8) $\pi(f) = \underset{h, x}{\text{Max:}}\ py(\ell(f, h), x) - w^h h - qx$

Second, using the above profit function, we can rewrite the indirect utility function (7) as

(9) $V = \underset{f, M}{\text{Max:}}\ U(T - Af - M, A\pi(f) + w^M M).$

Now, consider the maximization of profit on unit land, stated in (8). The Kuhn-Tucker conditions with respect to h and x are

(10) $py_\ell \ell_h \leq w^h$, $h \geq 0$, with complemetary slackness ss

(11) $py_x \leq q$, $x \geq 0$, with complementary slackness

Complementary slackness means that at least one of the two weak inequalities in an expression must be an equality. The interpretation of the above first order conditions is straightforward. In expression

(10), $py_e \ell_h$ is the (value of) marginal product of an hour of hired labor. If this marginal product is smaller than the wage rate for the hired worker, then no hired labor is employed; that is, $h = 0$. On the other hand, if hired labor is employed on the farm, then its quantity is determined by an equalization of the marginal product to the wage rate w^h.

For later use, we note certain properties of the profit function (8). The marginal increase in unit profit from expending own labor is $\pi_f(f)$. For brevity in expression, we refer to $\pi_f(f)$ as marginal profit from own labor. This marginal profit can be expressed, using (8) and the envelop theorem, as

(12) $$\pi_f = py_\ell \ell_f > 0$$

The marginal profit is positive because both y_ℓ and ℓ_f are positive. Another property of the conditional profit function is that it is strictly concave in f.[5] This implies

(13) $$\pi_{ff} < 0 \,;$$

that is, the marginal profit from own labor declines as more own labor is employed on the farm. Note further from (12) that the marginal product of effective labor can be expressed as $py_\ell = \pi_f/\ell_f$. Substituting this into (10), we can rewrite this optimality condition as

(14) $$\pi_f \ell_h / \ell_f < w^h, \; h \geqslant 0 \text{ with complementary slackness}$$

The above expression has a conceptual advantage in that, unlike (10), it allows us to view the choice of h solely as a function of f. In examining the qualitative nature of a farmer's choices concerning hired and own labor on farm, therefore, we do not need to pay any explicit attention to the farmer's choices concerning nonlabor inputs.

Next, consider the farmer's supply of his labor on his own farm, and to the market. The optimality conditions for the maximization problem (9), with respect to f and M respectively, are

(15) $$U_T / U_I \geqslant \pi_f \text{ and } f \geqslant 0, \text{ with complementary slackness,}$$

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5. This follows from the assumption that the technology set is convex and that there is some possibility of substitution in the technology.

(16) $U_T \; / \; U_l \geqslant w^M$, and $M \geqslant 0$, with complementary slackness.

Once again, the above expressions have a clear economic meaning; they show how the allocation of a farmer's own labor is determined through a comparison of the returns from labor to the marginal rate of substitution between leisure and income.

To summarize, the optimality conditions (14), (15) and (16) completely characterize whether the labor variables f, M and h are zero or positive for a farmer facing a given set of parameters, and also indicate what the magnitude of a labor variable is when it is positive. Further, as we shall see, it is analytically useful to view the determination of the labor transactions of a farmer as a two-step process. First, f and M are determined from (15) and (16). Then, h is determined from (14), given the preceding choice of f. In the next section, we shall use the above optimality conditions to predict the labor behavior of farmers with different farm sizes.[6]

2. Labor Transactions

For simplicity, we begin by examining the case in which the wage rate at which a farmer can hire himself out is the same as the wage rate he must pay to employ hired workers; that is, $w^h = w^M$. Much of this analysis carries over, as we shall see, to the case where w^h and w^M are different.

Recall that the three labor variables (f, M, h) can take zero or positive values. In principle, this means that there are eight possible types of farmers depending on whether they work on their own farm or not, whether they hire themselves out or not, and whether they hire in labor or not. Two of these eight types are ruled out because we do not consider those farms on which there is no production; that is, it is not possible to have $f = 0$, $h = 0$, and $M \geqslant 0$.

Two more types can be ruled out because we show that: *A farmer would not simultaneously hire himself out, and use hired labor on his farm, if the wage rates for hiring in and hiring out are the same.* The economic reason behind this result is obvious. If the market value of own and hired labor is the same, then the farmer is unequivocally

6. In predicting these patterns, we assume that all parameters, except the farm size, are the same for all farmers. Obviously, such an assumption is not required for empirical analysis.

better-off by reducing his labor supply to the market, using these labor hours on his own farm, and reducing the hired labor by the same number of hours. This is because own labor on farm is marginally more productive than hired labor. To see this result formally, suppose it was possible to have $h>0$, $M>0$, and $f \geqslant 0$. Then, (14), (15) and (16) yield: $\pi f \leqslant U_T / U_l = w^M = w^h = \pi_f / h_l / f$. The preceding expression, however, entails a contradiction because of (3). Thus, it is not possible to have $h>0, M>0$, and $ff \geqslant 0$. Our next objective is to examine the pattern of own labor use of the remaining types of farmer; their behavior concerning hired labor is examined later.

Pattern of own labor use. Using the optimality conditions (15) and (16), it is straightforward to show that a farmer must belong to one, and only one, of the five regimes depicted in Table 1. The first regime refers to those farmers who work on their own farm and hire themselves out; that is, f and M are both positive for these farmers. The corresponding characterization from (15) and (16) is presented in the first row of Table 1. Next, consider those farmers who work on their own farm, but do not hire themselves out that is, $f > 0$, and $M = 0$. The first order conditions for these farmers, from (15) and (16), yield: $U_T/U_l = \pi_f \geqslant_w M$. The two possible characterizations for these farmers are, therefore, represented as regimes 2 and 3. Similary, it can be verified that regimes 4 and 5 refer to those absentee landlords who neither work on their own farm nor hire themselves out.

The above characterizations of regimes yield a number of results. We show that the farm size increases as we move down the regimes in Table 1; that is, farmers in regime 2 have a larger farm size than those in regime 1. and so on. Further, within regime 1, f is a constant with respect to farm size, but M is decreasing in farm size. On the other hand, within regime 3, f is decreasing in farm size. The qualitative implications of theso important results can be summarized as follows.

(i) *Up to a certain farm size, own labor supply on the farm is constant per unit of land, and the numberof labor hours sold to the market declines as the land size increases.*

(ii) *Above a certain farm size, farmers do not hire themselves out, and their own labor on farm per unit land declines as the land size increases. Eventually, with increasing land size, own labor supply on farm may become zero.*

To establish these results we obtain the following derivative of U_T / U_A, using (4), (5) and (6).

Table 1

Regime	Own Labor On Farm (f)	Own Labor Sold to the Market (M)	Characterization
1	+	+	$U_T / U_I = \pi_f = w^M$
2	+	0	$U_T/U_I = \pi_f = w^M$
3	+	0	$U_T/U_I = \pi_f > w^M$
4	0	0	$U_T/U_I = \pi_f > w^M$
5	0	0	$U_T / U_I > \pi_f > w^M$

$$(17) \quad \frac{\partial}{\partial A} \frac{U_T}{U_A} = (U_I)^{-2} \, [(U_I U_{TI} - U_T U_{II}) (\pi + A\pi_f \frac{\partial f}{\partial A} + w^M \frac{\partial M}{\partial A}) - (U_I U_{TT} - U_T U_{IT}) \, (f + A \frac{\partial f}{\partial A} + \frac{\partial M}{\partial A})]$$

and assume that

$$(18) \quad U_{II} < 0, \; U_{TT} < 0, \text{ and } U_{IT} = U_{TI} \geqslant 0.$$

Now, consider regime 1. Since $\pi_f = w^M$, it follows that f is fixed within this regime. Also, $\partial (U_T / U_I) / \partial A = 0$ because $U_T/U_I = w^M$. We therefore substitute $\partial f/\partial A = 0$ into (17) and equate the resulting expression to zero. This yields

$$(19) \quad \partial M / \partial A < 0,$$

within regime 1. Further, note that regimes 1 and 2 have identical characterizations but M is positive in regime 1, whereas it is zero in regime 2. From (19), therefore, a farmer in regime 1 must have a smaller farm size than the one in regime 2.

Next, consider regime 3. Within this regime M is zero, and the condition for optimality is $U_T / U_I = \pi f$. A perturbation in the preceding equation with respect to A yields

$$(20) \qquad \frac{\partial}{\partial A}\;\frac{U_T}{U_l} = \pi_{ff}\;\frac{\partial f}{\partial A}$$

Substitute (17) into (20) and note that $\partial M/\partial A = 0$, and π_{ff} is negative. The resulting expression can be rearranged to yield

$$(21) \quad \partial f/\partial A < 0,$$

within regime 3; The above result also allows us to compare regime 3 to regimes 2 and 4. These regimes have the same condition for optimality. However, f is larger in regime 2 than in regime 3; this follows from (13) and from the fact that π_f equals w^M in regime 2, whereas $\pi_f < w^M$ in regime 3. On the other hand, f is zero in regime 4, whereas it is positive in regime 3. From (21), therefore, a farmer in regime 3 must have a larger (respectively, smaller) farm size than a farmer in regime 2 (respectively, regime 4).

The last comparison is that between regimes 4 and 5. In both cases f and M are zero. Correspondingly π_f is fixed and, thus, Table 1 shows that U_T / U_l is larger in regime 5 than in regime 4. Substituting $\partial f/\partial A = \partial M/\partial A = 0$ into (17), we find that the above difference in the magnitude of U_T / U_l is possible only if the farm size in regime 5 is larger than that in regime 4.

Pattern of hired labor use. In the beginning of this section, we have shown that it is not possible to have $M > 0$ and $h > 0$. Clearly, therefore, farmers in regime 1 do not hire workers. A parallel reasoning shows that the same is true in regime 2. Next, consider regimes 4 and 5. Since farmers in these regimes do not work on their own farms, they must hire workers because farm production is not possible otherwise. Also, the hired labor per unit of land is constant across different farm sizes within these regimes. This follows from noting that $f = 0$, and that the optimality condition, $\pi_f \ell_h / \ell_f = w^h$, determines h as a function of f.

The remaining regime withn which we need to investigate the pattern of hired labor is regime 3. Within this regime, h can be zero or positive and, from (21), f is decreasing in farm size. The relevant issue, thus is how h is affected by a change in f. It turns out that the answer depends critically on whether the marginal product of hired labor decreases or increases if the own labor input is decreased. To see this, consider those farmers who employ hired labor. For brevity, if

$m(f, h) \equiv \pi_f \ell_h / \ell_f$ denotes the marginal product of hired labor, then the optimality condition (14) is

(22) $m(f, h) = w^h$

Now, $m^h < 0$;[7] that is, the marginal product of hired labor declines with hired labor. Therefore, perturbing (22) with respect to f and h, and noting that $\partial f / \partial A < 0$, we obtain

(23) $\partial h / \partial A \gtreqless 0$ if $m_f \lesseqgtr 0$

Next, consider the sign of m_f. An increase in own labor has two opposite effects on the marginal product of hired labor. First, hired labor becomes more productive, and, thus, its marginal product declines. Second, effective labor input increases, and, therefore, the marginal product of hired labor increases. Hence, the sign of m_f depends on which one of the above two effects dominates. A more direct way to see this ambiguity is to examine the partial derivative of $m \equiv \pi_f \ell_h / \ell_f$ with respect to f. This yields: sign (m_f) = sign $(\eta - \mathcal{E})$; where $\eta = \partial ln (\ell_h / \ell_f) / \partial ln f > 0$ is the elasticity of the marginal rate of substitution between own and hired labor with respect to own labor; and $\mathcal{E} = -\partial ln \pi_f / \partial ln f > 0$ is the elasticity of the marginal profit from own labor with respect to own labor. Substitution of the above expression for m_f into (23) yields

(24) $\partial h / \partial A \gtrless 0$ if $\eta \lessgtr \varepsilon$.

The above results can be summarized as follows: (i) *No hired labor is employed at the lower end of the distribution of farm sizes.* (ii) *Hired labor is constant per unit of land at the higher end of the distribution of farm sizes.* (iii) *For those farmers in the intermediate range of farm sizes who employ hired labor, the pattern of hired labor is given by (24).*

Nonuniform wages. The entire analysis presented above remains unaffected, with one exception, if the wage rate for hiring workers is smaller or larger than the wage at which a farmer can hire himself out. The exception is that if w^M exceeds w^h, then it is possible that a farmer simultaneously employs hired labor, and hires himself out.

7. This is the second order condition corresponding to (22). Alternatively, it can be derived from the definition of m, under the assumption that $\ell_{fh} \geqslant 0$.

Further, if such a farmer also works on his own farm, then (14), (15), and (16) yield

$$\ell_h/\ell_f = w^H/w^M \tag{25}$$

This expression has such a remarkable property that, unlike those encountered earlier, it does not directly involve either the utility function or the profit (production) function. For the abovementioned farmers, therefore, expression (25) holds even if the farmers are facing different sets of parameters (prices and labor endowment, for example).[8]

3. Extensions

Household characteristics. Under the commonly made assumption that a household's choices can be represented through the maximization of a scalar aggregator (household utility function), it is straightforward to expand the above framework to include the heterogeneity of household composition. For a given household composition, the qualitative patterns of behavior across different farm sizes would continue to be similar to those identified in the previous section. Of course, the production choices made by households with different characteristics but with identical farm sizes would be different. One of the manifestations of such a difference would be that the farm size at which farmers switch regimes in Table 1 would be determined by the household composition.[9]

Wages and supervision. We have assumed that the wage rate paid to hired workers is generated in the market, and that, in particular, the wage rate is not directly influenced by the level of supervision provided by the farmer. Underlying this assumption is the view that the primary role of supervision is to improve the productivity of hired workers through management and coordination (see Rosen 1982). If, on the other hand, the primary effect of supervision is to reduce the on-the-job consumption of leisure by hired workers, then it can be modelled by requiring that a contract with a hired worker

8. Fewer assumptions concerning functional forms are, thus, required in estimating (25).

9. A further extension of the model outlined above is to treat f as a vector and allow the possibility that different types of individuals (adult versus children) may have significantly different abilities to supervise.

simultaneously specify the level of supervision and the wage rate.[10] Under the latter type of effect, we would expect farmers with larger farm size or smaller family size (who are able to provide less supervision) to pay lower wages to hired workers.[11]

4. Concluding Remarks

Though the critical role that supervision of hired labor plays in private farming has long been recognized, this phenomenon has not been adequately integrated in the theory and empirical analysis of farm behavior. The present paper provides a basis for such an integration by explicitly modelling the role and the determinants of supervision. We use this model to predict the patterns of labor transactions (that is, the quantity of own labor hired out versus used on farm, and the quantity of hired labor employed on farm), and demonstrate that these patterns are strikingly different than those which one would observe if supervision had no economic role to play.

A forceful example of how policy analysis is affected by an explicit recognition of supervision effects is provided by the issue of land rent. In the conventional model with no supervision effects, a standard implication of the constant returns to scale in production is that the unit land rent (net profit per unit land) is independent of the farm size. Naturally, therefore, there is no direct efficiency gain or loss, under this model, from a change in the distribution of land.

In contrast, the unit land rent can be quite different for different farmers in the presence of supervision effects. Specifically, it can be easily shown that the land rent is a decreasing function of farm size, at least within certain ranges of farm sizes. The economic reasoning is straightforward. Own labor is a fixed resource which is applied with

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10. Under each contract, supervision determines the probability of detecting shirking behavior. This, in combination with the hired worker's cost of being laid off and his (market determined) expected utility, yields the correspondence between the supervision level and the wage rate. See Calvo (1984), Ordover and Shapiro (1984), and references therein.

11. Another possible generalization is to incorporate the possibility that there is a spectrum of skills among hired workers (who can be hired at different wages, given any level of supervision), and that the efficacy of supervision is different for different types of skilled workers. Such a generalization would provide an endogenous selection of the types of hired workers which a farmer hires.

less intensity (that is, hours of own labor on unit land decline) as farm size increases. Further, the substitution of own labor by hired labor becomes increasingly more expensive as the intensity of the former declines. As a consequence, the economic value of an additional unit of land declines with increasing farm size.[12]

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12. The persistence of the differences in unit land rents obviously requires the presence of constraints in the credit markets.