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ABSTRACT

Labor markets in all economies are subject to transaction costs associated with recruiting, monitoring and supervising workers. Rural labor markets in developing economies, where institutions such as labor and contract law and formal employment assistance mechanisms are not in place, are regarded to be particularly sensitive to transaction cost conditions. The inherent difficulty of measuring transaction costs has limited studies on this topic.

In this paper, we analyze supervision activities reported in a cross-section survey of rice farmers in the Bicol region of the Philippines. This survey is unique because it provides supervision data at the farm task level. We present a simple optimization model in which supervision intensity increases the productivity of hired workers, which is assumed to be lower than that of family members due to the transaction costs. The model predicts that supervision intensity will increase with transaction costs. We use different institutional conditions to proxy for transaction costs, and estimate the demand for supervision time for four different classes of rice production tasks. The estimation strategy controls for selectivity in both hiring and supervising. The results show a positive effect of transaction costs on supervision intensity.

We then extend the analysis to a farm efficiency specification to test the proposition that supervision activities improve farm efficiency. This framework allows us to relate institutional conditions to farm efficiency directly and indirectly through their effect on supervision activities. We find that transaction costs have a negative direct effect on farm efficiency, but this is partially offset by the positive efficiency effects of increased supervision intensity. The results enable us to associate institutional conditions with transaction costs and to draw policy inferences regarding the value of improved institutional conditions.

KEYWORDS: Transaction Costs, Supervision, Labor Markets, Philippines

JEL CLASSIFICATIONS: 013, D23, J43, Q12

I. Introduction

Labor markets in all economies are subject to transaction costs associated with recruiting, monitoring and supervising workers. Transaction costs in the labor market typically arise due to information problems of two types: 1) moral hazard because the true work effort is not easily verifiable and enforceable, and 2) adverse selection because information on the attributes of heterogeneous workers is not readily available. Recruiting costs can also increase if communication and transportation networks are weak so that the labor markets are segmented. Transaction costs will be lower in environments where contract are easily enforced, information on workers and employers are readily available and labor markets are well connected. The level of transaction costs affects labor and land contract choices and family labor advantages. Rural labor markets in developing economies, where institutions such as labor and contract law and formal employment assistance mechanisms are not in place, are regarded to be particularly sensitive to transaction cost conditions. A number of studies of contract choice support this contention. The inherent difficulty of measuring transaction costs, however, has limited studies on this topic.

In this paper, we report an analysis of supervision activities based on a cross-section survey of rice farmers in the Bicol region in the Philippines. This survey is unique because it provides supervision data at the farm task level in addition to information on production activities and household characteristics over a range of institutional conditions. It also provides barangay (village) level variables that help us to quantify the institutional conditions. Our primary concern is to analyze the demand for supervision time on survey farms. We develop estimates of the effect of different institutional conditions on supervision time for four different types of rice production tasks.

We also extend the analysis to a farm efficiency specification to test the proposition that supervision activities improve farm efficiency. This framework allows us to relate institutional conditions to farm efficiency directly and indirectly through the effect on supervision activities. This enables us to associate institutional conditions with transaction costs and to draw policy inferences regarding the value of improved institutional conditions.

Only a few studies have formally studied the demand for supervision. Empirical studies are especially rare because most farm level surveys have not explicitly measured supervision intensities. Several studies have related the demand for supervision to wages and the size of work groups. Efficiency wage models suggest that supervision may be substituted by wage premiums when monitoring is costly (Bulow and Summers 1986). This justifies the finding of Groshen and Krueger (1990) and Kruse (1992) that wages and supervision intensity are negatively correlated. However, if variations in shirking costs among firms are more important than variations in monitoring costs, supervision and wages may be positively correlated (Neal 1993). That is, if wages are high, the cost of shirking is higher for employers. Supervision also depends on the size of the work group (Ewing and Payne 1999), but the sign of the effect is ambiguous: scale economies in supervision make monitoring more cost-efficient in larger work groups; on the other hand, large work groups are more difficult to supervise. To our knowledge, the literature has not addressed the relationship between institutional conditions (or transaction costs) and supervision. We hypothesize that the demand for supervision will be greater in high transaction cost environments.

In part II of this paper, we develop the specification utilized in this paper. In part III, we summarize the data. Part IV reports our supervision demand estimates. Part V reports our farm efficiency estimates. Part VI concludes with policy implications.

II. A Simple Model of Supervision Intensity

Assume that production is a function of effective labor (E) that is composed of family labor and hired labor, according to the following specification:

$$E = L^f + [\alpha + g(L^s/L^h + \beta\, L^f/L^h)]\, L^h \qquad (1)$$

where L^f is family labor, L^h is hired labor, and L^s is supervision (all in hours). Hence, family members provide two separate types of labor: (1) conventional labor input; and (2) direct supervision of hired workers. The effectiveness of hired labor is determined by the parameter α, the direct supervision intensity (L^s/L^h) and the indirect supervision intensity (L^f/L^h). The parameter α represents the efficiency of hired labor (relative to family labor) if there is no direct or indirect supervision. We assume that α is between zero and one, implying that if only hired labor is employed, the effectiveness of a unit of hired labor is lower than that of a unit of family labor if only family labor is employed. The most obvious reason for this assumption is moral hazard. Indirect supervision refers to the fact that family members working together with hired workers increases the effectiveness of the hired workers even if no direct supervision is performed. The coefficient β, which is assumed to be between zero and one, determines the relative effectiveness of indirect supervision intensity and direct supervision intensity. The latter is naturally assumed to be more effective (β<1). If family members and hired workers are employed concurrently, the parameter α has to be even smaller so that α+g()<1, otherwise if would be more efficient to use family workers for direct supervision only.

Other than working on the farm or supervising hired workers, family members also have the possibility to work off the farm. We allow the off-farm wage rate to be different from the wage paid to hired workers. If family members and hired workers are similar in their earnings capacity then the off-farm wage rate is expected to be lower than the wage paid to hired workers due to transaction costs. In this case we will not expect family members to work off the farm. Family members will work off the farm only if their earnings capacity is higher than that of hired workers.

The farm household is assumed to maximize income, which is the sum of farm income and off-farm income:

$$I = f(E) + w^n (L - L^f - L^s) - w^h L^h \qquad (2)$$

where I is income, f() is the production function, L is total time devoted to work activities by family members (we assume that the labor-leisure choice is separable), w^n is the off-farm wage and w^h is the wage paid to hired workers. Note that the price of farm output is normalized to 1.

Income maximization provides optimal values for hired labor, family labor, and direct supervision. Any of these variables can of course be zero. Hired labor may be zero on small farms in which the returns to family labor are higher than off-farm wages (Sadoulet et al. 1998). In this case there will also be no direct supervision. Family labor may be zero on farms in which the returns to family labor are lower than off-farm wages. Direct supervision may be zero on farms in which indirect supervision is almost as efficient as direct supervision.

The alternative cost of a unit of time of family members is the same regardless whether it is used for farm work or for direct supervision (it is the off-farm wage rate if family members work off the farm or the marginal rate of substitution between consumption and leisure otherwise). Hence, the income maximization problem is separable in the sense that family farm labor input and direct supervision can be derived by maximizing effective labor input, given the (positive) values of hired labor input and total family farm labor supply. The solutions to this maximization problem are:

$$L^f = (L^T - \delta L^h)/(1-\beta) \qquad (3)$$

$$L^s = (\delta L^h - \beta L^T)/(1-\beta)$$

where $L^T = L^f + L^s$ and $\delta = (g')^{-1}(1/(1-\beta))$. It can be shown that L^f is positive if $L^T/(\delta L^h)>1$, while L^s is positive if $L^T/(\delta L^h)<1/\beta$. Therefore, it is possible to have both L^f and L^s positive for reasonable values of β, although the admissible range for this is declining as β approaches 1. However, given that both L^f and L^s are positive, and plugging (3) into (2), income becomes linear in L^T and L^h and hence income maximization does not produce internal solutions for both L^T and L^h. This means that having both L^f and L^s positive is not compatible with income maximization. This result is supported by our data, which show that family labor and direct supervision coexist in the same task in only about 3% of the cases.

Therefore, the decision on whether to work on the farm and indirectly supervise hired workers, or to directly supervise only, is a discrete decision to be made by family members. Our focus in this paper is on the direct supervision activities, hence we continue by looking at families who chose the direct supervision path. For these families, plugging equation (1) in equation (2) and setting L^f to zero yields:

$$I = f\{[\alpha + g(L^s/L^h)]L^h\} + w^n (L - L^s) - w^h L^h \qquad (2)'$$

This can be maximized over L^h and L^s/L^h to get the optimal values of hired labor and supervision intensity, respectively. The first order conditions are:

$$pf'(E)\, g'(L^s/L^h) - w^n = 0 \qquad (4)$$

$$pf'(E)[\alpha + g(L^s/L^h)] - w^n L^s/L^h - w^h = 0$$

and the optimal supervision intensity can be derived from

$$\alpha + g(l) = g'(l)(l + w^h/w^n) \qquad (5)$$

where $l = L^s/L^h$ is the supervision intensity.

We cannot present closed-form solutions without specifying the g() function. However, we can derive the signs of the effects of wages (w^h and w^n) and transaction costs (which affect α) on supervision under the reasonable assumption that g() is a well behaved twice differentiable function with g'()>0 and g''()<0.

The supervision intensity, *l*, is a function of w^h, w^n and α. We obtain the first order conditions with respect to each of these variables by implicitly differentiating equation (5).

For the hired wage, w^h,

$$\frac{\partial l}{\partial w^h} = \frac{g'(l)}{-g''(l)w^n[l + \frac{w^h}{w^n}]} > 0 \qquad (6)$$

The hired labor wage has a positive effect on supervision intensity. This is because an increase in the hired wage increases the cost of shirking (lost wages) to the employer. In addition, a higher wage increases the cost of hiring labor and reduces the amount of hired labor through a movement along the demand curve. Effective labor can be partly restored by increasing the supervision intensity. This can be achieved by reducing family supervision proportionately less than the reduction in hired labor, or even increasing it. Here, we have ignored the efficiency wage argument where wages over and above the reservation wage are given to reduce shirking by increasing the cost of shirking to the worker.

For the off-farm wage, w^n,

$$\frac{\partial l}{\partial w^n} = \frac{g'(l)\frac{w^h}{(w^n)^2}}{g''(l)[l + \frac{w^h}{w^n}]} < 0 \qquad (7)$$

Supervision intensity will decrease with off-farm wages. The reasoning is quite straight-forward because off-farm wages increase the opportunity cost of the farmer's time.

For the shirking variable, α:

$$\frac{\partial \lambda}{\partial \alpha} = \frac{1}{g''(\lambda)[\lambda + \frac{w^h}{w^n}]} < 0 \qquad (8)$$

This tells us that supervision intensity decreases when hired labor is more effective in the absence of supervision. For example, if there is an effective incentive scheme (piece rate contracts, long-term contracts, tenancy etc.) that acts as a self-enforcement mechanism for worker effort, the need for direct supervision is less. We argue that the extent of shirking, or the magnitude of α, is a function of the institutional conditions of the village. We expect the extent of shirking to be less in areas with well-developed market institutions that provide alternative methods for work effort enforcement. Therefore, weaker institutional conditions lead to a lower α and more supervision.

A Graphical Representation

The simplest treatment of supervision economics considers laborers to be subject to "shirking" or lack of direction if unsupervised. Therefore supervision lowers hired labor costs by improving the effectiveness of hired labor. In figure 1, we represent "shirking" costs as a negative function of supervision intensity. In the previous section, we saw that the shirking costs increase when hired wages (w^h) increase, and when transaction costs are high due to institutional conditions (leading to a lower α) . Therefore, we treat hired wages and transaction costs as shifters of the shirking cost function. In figure 1, we illustrate four possibilities: (1) high wage, high transaction cost environment (curve A), (2) low wage, high transaction cost environment (curve B), (3) high wage, low transaction cost environment (curve C), and (4) low wage, low transaction cost environment (curve D).

We argue that transaction costs have a large effect on shirking costs. In low transaction cost environments, labor markets are more complete, searching and recruiting costs are lower because of job search programs etc., and legal institutions are in place to enforce efficient labor contracts.

The cost of providing supervision is the opportunity value of the farmer's time. The time for supervision must be diverted from off-farm work or from other farm tasks (including indirect supervision by working with other hired workers). For low levels of supervision, this joint work-supervision activity may be very low cost. The curve F represents the opportunity cost of supervision. If the farmer has an elastic supply of time, the opportunity cost will be horizontal line at the off-farm wage. However, we argue that most farmers are time constrained, as reflected by the very low levels of off-farm labor participation (DeSilva 2000). In this case, the opportunity cost of supervision is the marginal rate of substitution between consumption and leisure which is an increasing function of supervision intensity. In fact, it is likely that the marginal cost of supervision (slope of curve F) would approach infinity, and there will be a upper bound of supervision intensity at the labor time endowment level. The shift parameters for curve F is the off-farm wage and the labor time endowment of the farmer (as reflected by family size and demographic variables). The observed supervision intensity will be higher if the off-farm wage is low, and if the farmer has a large endowment of family labor.

The farmer selects the optimal level of supervision (S_A, S_B, S_C, S_D) that minimizes the sum of shirking and supervision costs (A+F, B+F, C+F, D+F). This provides net of supervision transaction costs of TC_A, TC_B, TC_C, TC_D.

Three points merit attention here: 1) Given the low cost of joint work-supervision at low levels of supervision, there is likely to be some minimum level of supervision (e.g. S_D) below which supervision is not reported as direct supervision by farm managers. We incorporate this in the empirical analysis by estimating a selectivity equation where a probit on the choice to supervise is specified as a function hired wages and transaction costs. 2) In our formulation, the chief determinant of supervision intensity is the level of transaction costs, i.e. $S_A - S_C > S_C - S_D$ and $S_B - S_D > S_A - S_B$. This claim is tested in the empirical analysis by comparing the wage effects with transaction cost effects. 3) The observed (net of supervision) transaction costs are represented by TC_A, TC_B, TC_C and TC_D. In figure 1, we see that, conditional on wages, observed transaction costs are higher in high transaction cost environments. However, the greater supervision intensity in high transaction cost areas would lead to a relatively larger reduction in observed transaction costs in these areas. We estimate farm efficiency equations to isolate these effects. We expect supervision intensity to have a positive effect on farm efficiency (by lowering observed transaction costs), and high transaction costs to have a direct negative effect on efficiency (by raising observed transaction costs). However, the assumption that high transaction cost environments have larger observed transaction costs is based on the assumption that the supervision cost function is fixed across environments. This may be unrealistic, because it is easy to visualize a remote village where higher transaction costs are offset by lower supervision costs (due to lower off-farm wages, larger endowments of family labor). In this case, we may find some cases where observed transaction costs (and efficiency) are lower in remote high transaction costs environments.

Econometric Specifications

As a preliminary step in the empirical analysis of the determinants of supervision intensity, we write the first-order approximation of the supervision intensity equation (the solution of equation 5) as

$$L^s/L^h = X^s\delta + v \qquad (9)$$

where X^s is a vector of explanatory variables including wages, utility shifters and farm production determinants, δ is a corresponding vector of coefficients, and v is a random approximation error. Accordingly, we also specify the demand for hired labor as

$$L^h = X^h\gamma + u \qquad (10)$$

When one wants to choose a suitable empirical model to estimate the coefficients of (9), two selectivity problems have to be addressed. First, some farms do not hire any outside labor and use family labor only. Here supervision is not relevant. Second, some farms that do hire workers, decide not to supervise them. Therefore, the sample of farms for which supervision intensity is positive is not a random sample, and hence the supervision intensity equation (9) cannot be estimated by ordinary least squares.

We try three different approaches to correct for selectivity. The first approach is to use a binary choice model for the hiring decision, and a censored regression model for the supervision intensity equation, which comes into effect only if the first decision is to hire workers. The two models are estimated jointly. Suppose now that we have a sample of farms that can be divided into three groups: group A includes farms who do not hire labor, group B includes farms who hire labor but do not supervise, and group C includes farms who hire labor and supervise. The likelihood function of this sample is:

$$\prod_A pr(L^h \leq 0) \text{ x } \prod_B pr(L^h > 0 \text{ and } L^s/L^h \leq 0) \text{ x}$$
$$\prod_C pr(L^h > 0 \text{ and } L^s/L^h > 0) cd(L^s/L^h \mid L^h > 0 \text{ and } L^s/L^h > 0) \qquad (11)$$

where $\prod_A$ is the product over all the observations belonging to group A, pr() stands for probability and cd(|) stands for conditional density. Assuming that u and v are jointly normally distributed with zero means, standard deviations of σ_u and σ_v, respectively, and a correlation coefficient ρ, the likelihood function can be written as:

$$\tilde{O}_A \Phi(- X^h\gamma/\sigma_u) \text{ x } \tilde{O}_B \Psi(X^h\gamma/\sigma_u , -X^s\delta/\sigma_v , \rho) \text{ x}$$

$$\tilde{O}_C \, \phi[(L^s/L^h - X^s\delta)/\sigma_v \qquad (11)'$$

where ϕ and Φ are the probability density function and cumulative distribution function, respectively, of the standard normal random variable, and Ψ is the cumulative distribution function of the standardized bivariate normal random variables. The coefficients γ, δ, σ_v, and ρ can be estimated by maximizing (11)'.

One shortcoming of this approach, which is similar to the shortcoming of the familiar Tobit model, is that the same coefficients and the same variables that determine the level of supervision intensity also determine whether to supervise or not. For example, if there are fixed costs associated with labor supervision, a variable that is related to these fixed costs will affect the decision to supervise but not how much to supervise, given that supervision is positive. Our second approach allows for a separate equation to determine whether to supervise. Specifically, this equation is formulated as:

$$M = X^m\mu + \varepsilon \qquad (12)$$

and supervision is performed when M>0. Now, supervision intensity is observed only when L^h>0 and M>0. We use a bivariate probit model with sample selection (Wynand and van Praag 1981) to model the selection in two stages. The standard bivariate probit model is modified to incorporate the fact that the supervision (M) exists only if hiring is positive. The likelihood function of this model is:

$$\tilde{O}_A \, pr(L^h \leq 0) \text{ x } \tilde{O}_B \, pr(L^h > 0 \text{ and } M \leq 0) \text{ x}$$

$$\tilde{O}_C \, pr(L^h > 0 \text{ and } M > 0) cd(L^s/L^h \mid L^h > 0 \text{ and } M > 0) \qquad (13)$$

Under the usual assumptions on the error terms, the likelihood function becomes

$$\prod_{A} -\Phi(b_1^{'}x_1) X \prod_{B} \Phi_2(-b_2^{'}x_2, b_1^{'}x_1, -r) X$$
$$\prod_{C} \Phi_2(b_2^{'}x_2, b_1^{'}x_1, r) \quad (13)'$$

where Φ_2 is the bivariate normal distribution function and ρ is the correlation coefficient between the two error terms. Jones (1992) applied this model to British data, and Garcia and Labeaga (1996) -to Spanish data. Both could not reject the independence assumption.

In the third model we use, a standard multinomial logit specification is used for the selection equation. The choice variable Y is defined as:

$$Y = \begin{cases} 0 & \text{if } L^h \leq 0 \\ 1 & \text{if } L^h > 0 \text{ and } M \leq 0 \\ 2 & \text{if } L^h > 0 \text{ and } M > 0 \end{cases}$$

and

$$\text{Prob}(Y = j) = \frac{e^{b_j^{'}x_i}}{1 + \sum_{k=1}^{2} e^{b_k^{'}x_i}} \quad \text{for } j = 0,1,2 \quad \text{and } b_0 = 0 \qquad (14)$$

The sample used in the supervision equation is based on the choice Y=2.

A Model of Farm Efficiency[1]

The supervision demand model tells us that institutional conditions play an important role in determining the intensity of supervision activities. In the second part of this paper, we estimate the direct and indirect (through supervision) effect of institutional conditions on farm efficiency using a stochastic production function approach (Aigner et. al 1977, Meeusen and van der Broeck 1977).

The production frontier, where Q is the output, and Z is a vector of observed inputs, such as land, labor, fertilizer, seeds, machinery and draft animals is formulated as follows:

$$\begin{aligned} &Q_i = f(Z_i; b)\exp(e_i - u_i) \\ &where \quad u_i = |U_i| \quad and \quad U_i \sim N(0, s_u^2) \qquad (15) \\ &and \quad e_i \sim N(0, s_e^2) \end{aligned}$$

We assume that the two error terms are distributed normal and half-normal respectively, and are independent of each other. The two-sided error term captures the effects of unobserved stochastic factors (e.g.weather shocks) and specification errors. The one-sided non-negative error term represents “technical inefficiency” of the farmer or, more precisely, the ratio of the observed to maximum feasible output, where maximum feasible output is determined by the stochastic production frontier (Lovell 1993).

Then, the technical efficiency (TE_i) of farmer i can be expressed as,

$$TE_i = \frac{Q_i}{[f(Z_i; b)\exp(e)]} = \exp\ (-u_i) \qquad (16)$$

[1] This discussion in this section borrows heavily from DeSilva (2000)

It is straight-forward to estimate the stochastic frontier model using maximum likelihood methods. Since our aim is to determine the effect of institutional conditions and supervision on farm efficiency, we further define the one-sided error term, u, as follows:

$$u_i = -\log TE_i = a_1 F_i + a_2 B_i + a_3 S_i + e_i \qquad (17)$$

where F is a vector of farm-level variables, B is a vector of institutional variables at the barangay level and S is the level of supervision intensity. The error term e_i is defined so that u is non-negative and half-normally distributed.

The simplest way to estimate this efficiency equation is to regress the technical efficiency estimates obtained from the stochastic frontier estimation on a set of explanatory variables (e.g. Pitt and Lee 1981, Kalirajan 1981). However, such a two-step method is fundamentally incorrect because the dependent variable in the OLS specification of equation (17) was assumed one-sided, non-positive and identically distributed in the first step (Kumbhakar et. al 1991, Reifschneider and Stevenson 1991, Battese and Coelli 1995). We adopt the more appropriate method of jointly estimating the frontier and efficiency equations using maximum likelihood methods. We use the version of this method proposed in Battese and Coelli (1995).

The coefficient a_2 tells us the efficiency effect of the institutional environment, which can be interpreted as a measure of transaction costs. If an explicit measure of supervision was not included, the estimate of a_2 will be biased because the demand for supervision is also a function of transaction costs as argued in the previous section. In particular, we expect the estimate of a_2 to be smaller in absolute value when supervision is excluded because higher transaction costs may be partially compensated by supervision. Although the inclusion of supervision gives us a better transaction cost measure, this may cause endogeneity problems because both farm inefficiency and supervision intensity may be correlated with the same unobserved variables (e.g. motivation, entrepreneurship). We correct for this by using the predicted supervision from the demand equations as a proxy variable.

III. Data

The data used in this research are from the 1994 Bicol Multipurpose Survey, which was conducted in Camarines Sur, the main province of the Bicol region of the Philippines. The sample consists of 691 households from 59 different villages (barangays). The survey collected detailed information on demographics, health, income, expenditures, and farm production. The most detailed information collected was on the 264 households engaged in rice cultivation. Some of the households were cultivating rice on more than one plot, and most of them had two crops per year. Hence, we have a total of 652 observations on rice cultivation units by farm, plot, and season.

For each cultivation unit, labor input is reported for each of 16 work activities defined in Table 1. The labor input is also reported separately for hired labor, family labor, and exchange labor. Exchange labor is ignored because it occurs in less that one percent of the activities. In most activities, either hired labor or family labor are reported. Hired labor and family labor are reported for the same work activity in less than 3% of the cases. The cases in which hired labor is employed consist of slightly more than one half of the cases, according to Table 1. However, there is considerable variation across work activities. We have grouped work activities into four major types: land preparation, planting, caring, and harvesting. Although there is still variation in the fraction of hired labor activities within the major types, much of the variation seems to be between types. In harvesting activities, for example, hired labor consists of 85% of the cases, while it is less than a third in caring activities. Table 1 also shows that almost two thirds of the hired labor activities are supervised by family members. This fraction also varies across and within types of activities. Also reported is the total amount of supervision time. From this we derive the supervision intensity index L^s/L^h which is our dependent variable.

We estimate our models separately for the four different types of activities. We also tried to estimate the models separately for each activity, but some of the samples were too small and many of the results lacked statistical significance. As explanatory variables in the supervision intensity equation, we use several groups of variables. The first group include hired labor wage and the off-farm wage, which come straight out of our theoretical model. The second group consists of variables which determine the effectiveness of supervision, reflecting the functional form of g() in our theoretical model. These include the number of hired workers, a dummy indicator for hired workers that are employed under a time rate contract, a dummy indicator for hired workers that were hired through a labor contractor, the land area of the farm, a dummy for the rainy season, a dummy for plots which are located in the same barangay as the residence of the farm operator, and two dummies for using gravity irrigation and pump irrigation (the excluded group is rainfed plots). Also included in this group are a set of barangay-specific variables which proxy for labor market conditions. These are the distance to the nearest city, a dummy for new road construction in the last decade, and an urbanization index. The third group of explanatory variables are household head characteristics and household demographic variables. These could affect the effectiveness of supervision and also the amount of time devoted to work by family members (L). These variables are the numbers of males and females in the household, and the sex, age and education of the head of household. Table 2 includes definitions of the explanatory variables and their descriptive statistics.

IV. Supervision Demand Estimates

1. *Land Preparation Activities*

The first column in Table 3 reports the results of the tobit supervision model with selection. In the selection equation, the barangay-level transaction cost variables show that there is more hiring in areas with new roads and those that are less urbanized. The presence of new roads lowers transportation costs and helps the labor market to function better. However, the urbanization effect is counter-intuitive and difficult to interpret. The results also show that the probability of hiring-in labor is positively affected by the farm size, age and education of the farmer, number of female adults in the household and the presence of pump and gravity irrigation. The first four effects suggest that laborers are hired when the household has a large land to labor endowment ratio. Education of the farmer appears to reflect the opportunity cost of cultivation. The positive irrigation effects indicate that irrigated land is more intensively cultivated, and requires more labor.

The tobit supervision equation is estimated for all households that hire-in labor. The farms that do not supervise are treated as zero-censored observations. The transaction cost variables reveal that supervision intensity is higher in barangays with higher transaction costs. Specifically, farmers in barangays that are further from cities and those without new roads supervise more intensively. In addition, the supervision intensity increases with the number of hired workers, and decreases with farm size. The first effect supports the idea that large work groups are more difficult to supervise. The second effect shows that opportunity costs of supervising increase as when the hired workers are spatially dispersed. We also find that male farmers supervise more intensively.

The second column reports the results of the linear supervision model with a bivariate probit selection rule. The bivariate probit selection rule first estimates the hiring-in choice and then, conditional on hiring-in, estimates the choice to supervise. The coefficient estimates of the hiring-in equation is very similar to the probit selection equation in Model 1. Conditional on hiring-in, we see that the number of workers and the gender of farmer has a positive effect on the choice to supervise. The work group size effect is interesting because it suggests the existence of some fixed costs that makes direct supervision inefficient when there are only a few hired workers.

The linear supervision equation is estimated only for farmers that supervise. The selectivity correction term is significant at the 10% level. Here again, we see a substantial positive effect of transaction costs (distance to city and new roads) on supervision intensity. We also find that older and more educated farmers supervise less intensively. This may be because they are more efficient at supervising, or because their opportunity costs are larger. Unlike in the tobit supervision equation, the worker and gender effects are not significant in the second stage equation. By estimating the choice to supervise and the extent of supervision separately, we are thus able to separate out the fixed and variable costs of supervision.

The third column reports the linear supervision equation with a selectivity correction based on a multinomial logit selection rule. The results are reported for two choices, hiring without supervision and hiring with supervision, relative to not hiring. Barangays with new roads are more likely to hire-in workers with and without supervision. Similarly, age and education of the farmer and the presence of irrigation increases the likelihood of hiring in both cases. Less urbanized barangays are more likely to hire-in with supervision relative to both of the other choices. In addition, households with larger farms, less male (and more female) adults, and a female head are more likely to hire-in without supervision. These results suggest that households with high land to labor endowment ratios (as reflected by the farm size and demographic variables) are likely to hire-in but do not have sufficient family labor to directly supervise.

The selectivity term in the supervision equation is once again significant at the 10% level. The rest of the coefficient estimates are qualitatively similar to that of Model 2. In particular, the transaction costs have a positive effect on supervision intensity.

2. Planting Tasks

The first column in Table 4 reports the results of the tobit supervision model with selection for planting tasks. In the selection equation, the barangay-level transaction cost variables have significant effects on the choice to hire-in. Households in the more urban barangays and in those with new roads participate more in the hired labor market. Conditional on these two variables, the probability of hiring-in increases with distance to city. The farm size, age, education, irrigation and household composition variables have similar effects to that of land preparation tasks.

In the tobit supervision equation, only the new roads variable has a significant expected sign among the transaction cost variables. The supervision intensity also increases with the number of hired workers and decreases with farm size. We also find that the type of labor contract has an important effect on the extent of supervision. For example, workers that are hired on a time-rate basis are supervised more because the time-rate contracts do not provide a self-enforcement mechanism for the work effort of laborers. Workers that are hired as teams are supervised less intensively possibly because of scale economies associated with teams, or alternative supervision methods (by team leaders etc.).

The second column reports the results of the linear supervision model with a bivariate probit selection rule. Once again, the coefficient estimates of the hiring-in equation is very similar to the probit selection equation in Model 1. Like the land preparation tasks, both the number of workers and the gender of farmer have a positive effect on the choice to supervise conditional on hiring-in. For planting tasks, the distance to city, wage and time-rate contracts also have positive effect on the choice to supervise. The farm size and teams have negative effects. These coefficients have the expected signs. The wage effect is especially interesting, and supports the conclusion of the theoretical model that the reduction in hired labor due to high wages can be partially offset by increasing the supervision intensity.

The selectivity term is not significant in the supervision equation. The transaction cost variables have the expected signs, although only the urbanization effect is significant. We also find a positive education effect and negative gender and team effects.

The third column reports the linear supervision equation with a multinomial logit selection rule. Barangays that are more urbanized and have new roads are more likely to hire-in workers with and without supervision. The barangays that are distant from cities are more likely to hire workers with supervision. Age, education and irrigation increase the likelihood of hiring in both cases. The number of male adults in the household decrease the likelihood of hiring. However, the farm size and gender of household head appear to affect only the decision to hire-in without supervision.

The selectivity term in the supervision equation is significant at the 5% level. Among the barangay variables, urbanization and new roads have the expected signs and are significant. The distance to city is insignificant. The wage effects are also negligible. However, we find that supervision intensity increases if the household has male adults, if the farmer is resident in the same village as the farm and if the farm size is large. The first two effects are intuitive and indicate the availability of family labor to supervise. The third effect is the opposite of what we saw for land preparation, and is difficult to interpret.

3. Caring Tasks

The first column in Table 5 reports the results of the tobit supervision model with selection for caring tasks. The estimates of the selection equation are qualitatively similar to the estimates for planting tasks. At the barangay level, distance to city, new roads, and urbanization increase the probability of hiring-in. At the household level, the farm size, number of female adults, age, education, resident status and irrigation have significant positive effects. The number of male adults has a negative effect.

In the tobit supervision equation, supervision intensity is high in barangays that are distant to cities. However, the new roads variables has the wrong sign in this case. The supervision intensity also increases with age, education and irrigation. The number of male adults is significant, but also has an unexpected sign. The wage and contract variables are insignficant. The somewhat unexpected results may be caused by the fact that the tobit equation confounds the choice to supervise with the intensity of supervision.

The bivariate probit selection equation failed to converge under several different algorithms and convergence criteria. This may be due to the small percentage (15%) of household engage in both hiring and supervision for these tasks. The second column reports the linear supervision equation with a multinomial logit selection rule. The results are similar to what we saw for planting tasks. Distance to city is positive but not significant, while new roads are positive and significant. Unlike for planting, less urban barangays have lower probability of hiring only when there is no supervision. Among the household level variables, age, education and irrigation have a significant positive effect on hiring. The demographic variables also have the expected signs. Farm size and the resident status have positive effects only in the case of hiring without supervision.

The selectivity term is not significant in the supervision equation. In fact, only farm size and the number of male adults have a significant effect on supervision intensity. The high standard errors in these estimates reveal potential specification problems, or the inappropriateness of the supervision model itself in the case of caring tasks. The weak results, and the convergence problems in Model 3, may both be caused by the fact that caring is largely undertaken by family members and supervision in the form that is observed in planting, harvesting and plowing, does not exist for these tasks.

4. Harvesting Tasks

The first column in Table 6 reports the results of the tobit supervision model with selection for planting tasks. In the selection equation, the barangay variables are not significant. Education and irrigation have significant positive effects on hiring. We also find a strong seasonal effect in hiring for harvesting.

In the tobit supervision equation, distance to city and new roads have the expected signs but only the latter is significant at 10% level. The supervision intensity also increases with irrigation, and decreases with time rate contracts and education. The contract effect is the opposite of what the standard principal-agent model suggests.

The second column reports the results of the linear supervision model with a bivariate probit selection rule. The first stage probit equation is similar to the selection equation in Model 1, but gives stronger estimates. The choice to supervise, conditional on the choice to hire, is negatively affected by new roads and education and positively affected by wage, number of female adults and the gender (male) of farmer. As in the case of planting, the wage effect confirms our theoretical result that supervision is positively related wages.

The selectivity term is not significant in the supervision equation. The distance to city and new roads have the expected signs, but only the former is significant at 10% level. However, we find a strong negative effect for the number of workers indicating scale economies in supervision, and a strong negative effect for time rate contracts. The negative time rate effect is peculiar to the harvesting tasks.

The third column reports the linear supervision equation with a multinomial logit selection rule. The barangay effects are weak in the selection equation, except for a strong negative effect for new roads in hiring with supervision. Seasonal effects are again more pronounced than for the other types of tasks. In addition, irrigation and the number of female adults increase the probability of hiring with supervision, and while education, area and gender (female) of the head increases the probability of hiring without supervision.

The selectivity term in the supervision equation is significant at the 5% level. Among the barangay variables, distance to city and new roads have the expected signs. This adds to the evidence that supervision intensity is generally higher in environments with high transaction costs. We also find a strong negative area, age and season effects, and the usual positive irrigation effects. The wage is once again insignificant in determining the supervision intensity. The results seem to indicate that the wage effect, if they exist at all, are captured in the choice to supervise and not in the intensity of supervision.

V. The Efficiency Estimations

Table 7 reports the results of the joint estimation of a stochastic production frontier and its associated efficiency equation. The usual inputs (land, labor, fertilizer etc.) are included in the production function. The equation for the one-sided efficiency error term is specified with two sets of variables: The first includes farmer level variables such as age, education, ownership status, resident status and supervision intensity. The second includes barangay-level variables such as distance to city, urbanization, population and construction of new roads. The latter variables are included to capture transaction costs at the market-level. The main purpose of this exercise is to determine whether intensive supervision increases farm efficiency. Because barangay level transaction costs are likely to be highly correlated with supervision intensity, we estimate the model with and without the barangay variables so that the direct and indirect (through supervision) effects of transaction costs on efficiency can be identified. Because supervision intensity may be an endogenous variable, we also estimate the model using the predicted values from the supervision equation in Model 1 as a proxy for supervision intensity.

The first column reports results with the actual supervision intensities. The second column re-estimates with predicted supervision values. For each case, we report the estimates with and without the barangay variables. The production function estimates are very similar in all four cases. All inputs except farm animals have a positive sign, although irrigation is not significant. Land and labor elasticities are the largest as expected. A puzzling result is the substantial decreasing returns to scale (about 0.75) in the production function. This may indicate that the simple Cobb-Douglas form is not appropriate in this case. The negative estimates for farm animals is also likely to arise from the constant elasticity of substitution assumptions because farm animals can be thought of as an inferior substitute (in some cases) to tractors.

In the efficiency equation, we find the expected efficiency effect of supervision. When the actual supervision intensity is used and the barangay variables are omitted, the efficiency effects are large (8.24) and significant at 10% level. When barangay variables are included, the magnitude of the effect drops by about one-half (4.36) because the barangay variables independently have efficiency effects. When the predicted supervision intensity is used, the efficiency effects are still positive but much smaller and less significant. Here again, the inclusion of barangay variables reduces the magnitude of the effect. In addition the supervision effects, we find that farmers who are male, more educated, older and resident in the same village are more efficient. Owner-farmers, on the other hand, appear to be less efficient than tenants. This may reflect a selection bias, because more enterprising farmers may have obtained leasehold lands under land reforms.

Among the barangay variables, lower transaction costs appear to increase efficiency. Specifically, we find that farms in more populated and urbanized barangays and those with new roads are more efficient. The only surprising result is the positive efficiency effect of the distance to city. This tells us that conditional on urbanization, population and other included variables, the barangays that are farther from cities are more efficient. This may be a result peculiar to this sample that arises due to the correlation between favorable climate and soil conditions with the distance to cities. The direct inclusion of soil and climate variables would help to resolve this ambiguity.

VI. **Conclusions**

Direct supervision of hired workers is a directly unproductive activity that diverts a farmer's valuable time from other income generating activities. A farmer would engage in direct supervision only if the effort of workers cannot be enforced adequately by self-enforcement mechanisms such as contracts. The primary objective of this paper was to establish whether farmers respond to a weak institutional environment (where there is little scope for formal contracting) by increasing the direct supervision of workers. Our unique data set from the Bicol regions allows us to explicitly estimate supervision demand equations. We measure transaction costs with barangay (village) level indicators of urbanization and access to markets. Our results confirm that barangay-level transaction costs increase the intensity of supervision for all types of farm tasks. Improving labor and contract laws and the access to markets will reduce the need for direct supervision and enable farmers to intensify their own labor inputs in the farm or work in off-farm activities.

We also test the hypothesis that supervision activity increases farm efficiency. This is done by estimating production frontiers with both transaction costs and supervision intensity as determinants of farm efficiency. As expected, we find that transaction costs decrease efficiency, but this effect is partially offset by the positive supervision effect. This further supports our initial claim that direct supervision is a reaction to a weak institutional environment.

The efficiency estimates can also be used to construct a barangay (village) level index of transaction costs. We interpret transaction costs as the component of observed farm efficiency explained by barangay level institutional variables. Because we include a measure of supervision intensity in the efficiency estimates, the index represents the transaction costs net of supervision. In future work, we plan to use this measure to test for transaction cost effects in a variety of farm and household decision making issues. This will help expand the empirical literature on transaction costs which has so far been limited to a handful of studies (Lanzona and Evenson 1997).

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Figure 1: Graphical Representation of Supervision and Transaction Costs

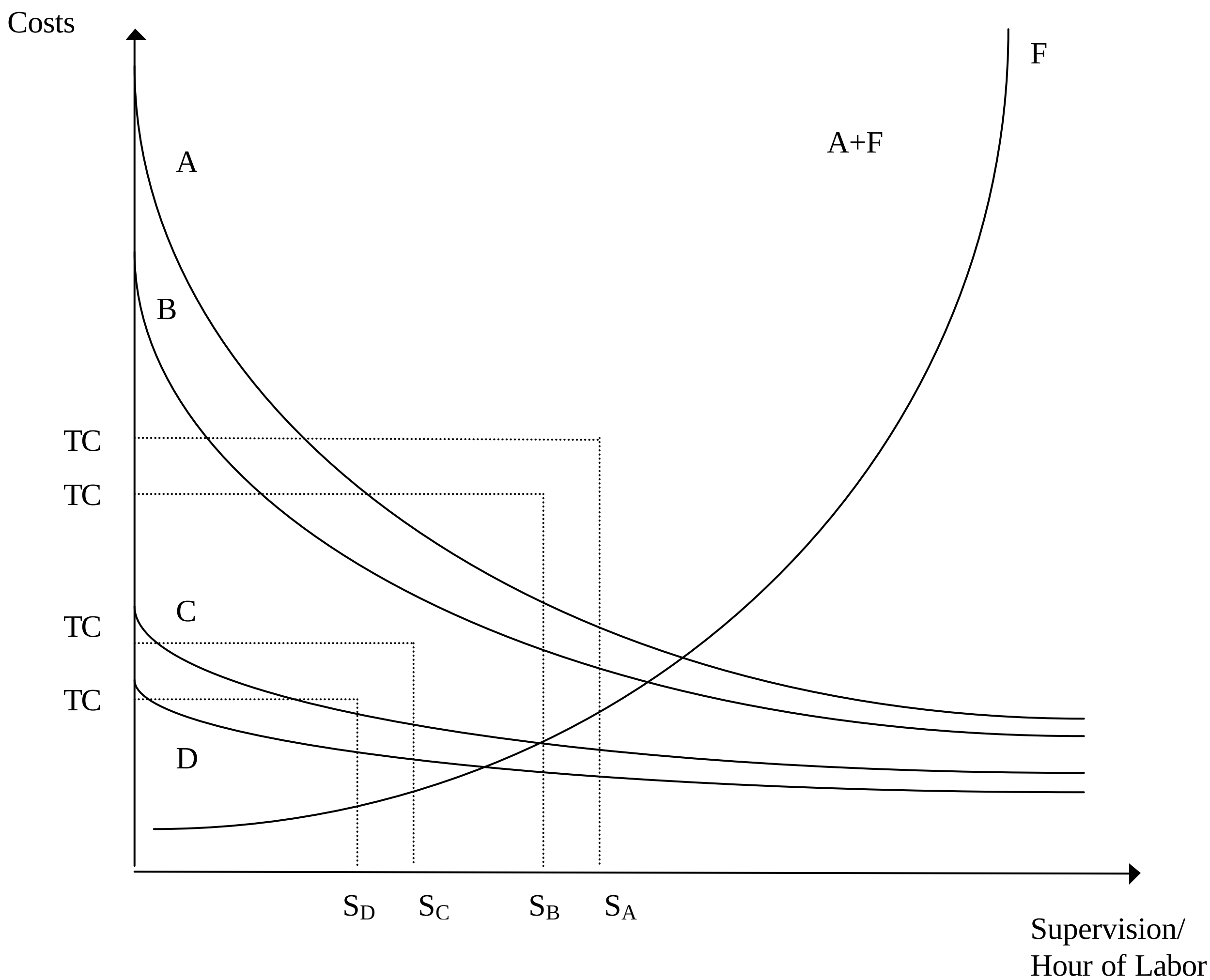

Table 1. Number of cases, cases with hired workers, and the incidence of supervision

Type of activity		Activity		Number	Cases with hired workers		Cases with supervision	
Number	**Name**	**Number**	**Name**	**of cases**	**Number**	**Fraction**	**Number**	**Fraction**
1	Land Preparation	1	Tractor labor	562	455	0.81	314	0.69
		2	Animal labor	485	286	0.59	196	0.69
		3	Repair of dikes	644	285	0.44	147	0.52
		subtotal		**1691**	**1026**	**0.61**	**657**	**0.64**
2	Planting	4	Seedbed preparation	352	74	0.21	26	0.35
		5	Seedbed care	330	31	0.09	5	0.16
		6	Bundling of seedlings	305	155	0.51	87	0.56
		7	Pre-transplant measurement	156	106	0.68	56	0.53
		8	Plant/transplant	665	420	0.63	275	0.65
		subtotal		**1808**	**786**	**0.43**	**449**	**0.57**
3	Caring	9	Weeding	483	227	0.47	131	0.58
		10	Fertilizing	566	145	0.26	79	0.54
		11	Chemical application	611	213	0.35	108	0.51
		15	Irrigation control	312	53	0.17	11	0.21
		subtotal		**1972**	**638**	**0.32**	**329**	**0.52**
4	Harvesting	12	Harvesting	612	520	0.85	356	0.68
		13	Threshing	571	498	0.87	398	0.8
		14	Harvesting/threshing	47	30	0.64	24	0.8
		16	Pre-harvest activities	8	7	0.88	0	0
		subtotal		**1238**	**1055**	**0.85**	**778**	**0.74**
	Total			**6710**	**3505**	**0.52**	**2213**	**0.63**

Table 2 : Descriptive Statistics

Name	Mean	Definition
Supervision Intensity	0.2316	Supervision intensity (number of direct supervision hours divided by hours of hired work.
HIRE	0.5477	Dummy for the existence of hired labor.
Number of Workers	4.2873	Number of hired workers.a
Wage	76.335	Daily wage of hired workers (peso).a
Opportunity Wage	52.254	Opportunity daily wage of family members (peso), derived from off-farm labor earnings.
Time Rate Contract (Dummy)	0.3383	Dummy for a time-rate labor contract.
Team Contract (Dummy)	0.076	Dummy for hiring workers through a contractor.
Farm Size	208.61	Land area of the farm (hectares/100).
No. Male Adults	3.8158	Number of adult male household members.
No. Female Adults	3.815	Number of adult female household members.
Season	0.5337	Dummy for the rainy season.
Sex of Household Head	0.7927	Dummy for a male head of household.
Education of Household Head	6.8403	Years of schooling of the head of household.
Age of Household Head	58.145	Age of household head.
Gravity Irrigation (Dummy)	0.4068	Dummy for using gravity irrigation.
Pump Irrigation (Dummy)	0.2271	Dummy for using pump irrigation.
Location (Dummy)	0.7908	Dummy for plots that are located in the same barangay as the residence of the household head.
Distance to City	23.648	Distance of barangay to nearest city (km).
New Road Construction (Dummy)	0.7246	Dummy for new road construction since 1983.
Urbanization	2.3925	Urbanization index (5=lowest, 1-highest).

a. the mean is calculated using observations with hired workers only.

Table 3: Land Preparation (Type 1) Tasks: Selection Equations

Type of Variable	Variable	(1) Probit/Tobit	(2) Bivariate Probit/OLS		(3) Mult. Logit/OLS	
		Hire=1	Hire=1	Sup=1|Hire=1	Hire=1 & Sup=0	Hire=1 & Sup=1
	Constant	-1.2178	-1.2163	-0.8159	-2.0755	-2.7932
		-3.52	-3.53	-0.81	-3.35	-4.75
Household	No. Male Adults	-0.0365	-0.0384	0.0308	-0.1153	-0.0322
		-1.74	-1.84	1.04	-2.92	-0.92
	No. Female Adults	0.0559	0.0577	-0.0347	0.1425	0.0682
		2.21	2.27	-0.93	3.22	1.64
	Sex of House. Head	-0.1457	-0.1315	0.3534	-0.4960	-0.0193
		-1.39	-1.25	2.40	-2.61	-0.10
	Education of Head	0.0862	0.0867	0.0300	0.1186	0.1561
		6.81	6.85	1.01	4.91	6.84
	Age of Head	0.0193	0.0191	0.0067	0.0266	0.0353
		4.63	4.60	0.86	3.47	4.93
Farm	Farm Size	0.0003	0.0003	-0.0002	0.0010	0.0003
		2.66	2.54	-1.14	4.11	1.37
	Season	-0.0958	-0.0945	-0.1012	-0.1023	-0.2019
		-1.28	-1.27	-1.09	-0.69	-1.47
	Gravity Irrigation	0.3623	0.3760	-0.2372	0.8242	0.4545
		3.98	4.14	-1.19	4.72	2.79
	Pump Irrigation	0.5511	0.5551	0.1415	0.8755	0.9955
		5.14	5.18	0.60	4.13	5.25
	Location	0.0343	0.0383	0.2278	-0.3831	0.1418
		0.32	0.36	1.77	-1.98	0.74
Labor Market	No. Hired Workers			0.1362		
				2.97		
	Wage			0.0014		
				1.42		
	Opportunity Wage			-0.0026		
				-0.91		
	Time Rate Contract			0.1145		
				0.89		
	Team Contract			0.0562		
				0.41		
Barangay	Distance to City	-0.0025	-0.0027	-0.0018	-0.0030	-0.0065
		-1.02	-1.08	-0.50	-0.60	-1.40
	Road Construction	0.2682	0.2515	-0.0421	0.4599	0.4083
		2.72	2.59	-0.27	2.50	2.41
	Urbanization Index	0.0685	0.0699	0.0374	0.0426	0.1490
		2.04	2.09	0.82	0.67	2.60
Task Dummies	Animal Labor	-0.8541	-0.8532	-0.2089	-1.3657	-1.4946
(Tractor Labor =0)		-8.43	-8.46	-0.70	-6.58	-8.24
	Repair of Dikes	-1.2151	-1.2144	-0.7717	-1.5045	-2.3800
		-12.83	-12.82	-2.14	-7.93	-13.17
rho			0.3531			
			0.54			
Observations		1382		1382	1434	
Log Likelihood		-1555.049		-1270.295	-1338.377	

NOTE: t-statistics are reported below each coefficient

Table 3 (continued): Land Preparation (Type 1) Tasks - Supervision Demand Equations

Type of Variable	Variable	(1) Probit/Tobit	(2) Bivariate Probit/OLS	(3) Mult. Logit/OLS
	Constant	0.0007	1.9192	1.6961
		0.00	2.61	2.64
Household	No. Male Adults	0.0231	0.0049	0.0005
		1.40	0.45	0.04
	No. Female Adults	-0.0120	0.0062	0.0082
		-0.53	0.45	0.60
	Sex of Household Head	0.2011	-0.0484	-0.0180
		2.53	-0.57	-0.24
	Education of House. Head	-0.0071	-0.0436	-0.0395
		-0.31	-2.98	-2.97
	Age of Household Head	-0.0008	-0.0076	-0.0069
		-0.14	-1.93	-1.85
Farm	Farm Size	-0.0003	-0.0001	-0.0001
		-2.24	-1.18	-0.79
	Season	-0.0138	0.0791	0.0638
		-0.24	1.50	1.29
	Gravity Irrigation	-0.1436	0.0007	-0.0083
		-1.25	0.01	-0.14
	Pump Irrigation	-0.1218	-0.3292	-0.3074
		-0.74	-3.04	-2.99
	Location	0.1559	0.0287	0.0257
		1.75	0.36	0.32
Labor Market	No. of Hired Workers	0.0571	-0.0216	0.0095
		2.23	-0.90	0.66
	Wage	0.0004	-0.0006	-0.0002
		0.67	-1.24	-0.48
	Opportunity Wage of Farmer	-0.0006	0.0013	0.0007
		-0.32	0.84	0.46
	Time Rate Contract	0.0293	-0.0715	-0.0351
		0.37	-1.08	-0.56
	Team Contract	0.1290	0.1149	0.1339
		1.63	1.76	2.09
Barangay	Distance to City	0.0055	0.0085	0.0087
		2.71	4.87	4.94
	New Road Construction	-0.2086	-0.2813	-0.2800
		-2.29	-4.30	-4.25
	Urbanization Index	0.0323	0.0076	0.0032
		1.01	0.32	0.13
Task Dummies	Animal Labor	-0.0140	0.2376	0.1958
(Tractor Labor =0)		-0.06	1.71	1.59
	Repair of Dikes	-0.2621	0.4325	0.3420
		-0.81	1.55	1.43
Sigma (1)		0.6967		
		37.88		
Rho (1)		-0.0506	-0.6972	-0.5822
Lambda (2) & (3)		-0.07	-1.77	-1.71
Observations		833	531	531
R-squared			0.17612	0.17547

NOTE: t-statistics are reported below each coefficient

Table 4: Planting (Type 2) Tasks - Selection Equations

Type of Variable	Variable	(1) Probit/Tobit	(2) Bivariate Probit/OLS		(3) Mult. Logit/OLS	
		Hire=1	Hire=1	Sup=1 |Hire=1	Hire=1 & Sup=0	Hire=1 & Sup=1
	Constant	-2.6287	-2.6308	-2.5009	-3.7900	-6.0628
		-7.50	-7.51	-1.91	-5.81	-8.83
Household	No. Male Adults	-0.1209	-0.1240	-0.0135	-0.2460	-0.2085
		-6.05	-6.16	-0.27	-6.09	-5.47
	No. Female Adults	0.0314	0.0332	-0.0103	0.0255	0.0574
		1.23	1.29	-0.29	0.58	1.31
	Sex of Household Head	-0.1513	-0.1373	0.5940	-0.7656	0.2535
		-1.40	-1.27	3.54	-4.29	1.27
	Education of Head	0.0866	0.0847	-0.0096	0.1475	0.1349
		6.31	6.21	-0.33	5.88	5.27
	Age of Household Head	0.0107	0.0104	0.0070	0.0136	0.0247
		2.54	2.49	1.03	1.79	3.24
Farm	Farm Size	0.0003	0.0003	-0.0008	0.0010	-0.0001
		2.68	2.71	-3.31	5.86	-0.23
	Season	-0.0219	-0.0223	0.0440	-0.0824	-0.0114
		-0.27	-0.28	0.40	-0.54	-0.07
	Gravity Irrigation	0.8063	0.8223	0.0504	1.2225	1.5438
		7.88	8.03	0.18	6.47	8.11
	Pump Irrigation	0.4390	0.4445	-0.1461	0.6841	0.6326
		3.55	3.57	-0.56	2.83	2.66
	Location	-0.1055	-0.0969	-0.1741	-0.1520	-0.3578
		-0.99	-0.91	-1.08	-0.78	-1.84
Labor Market	No. of Hired Workers			0.0496		
				4.52		
	Wage			0.0115		
				3.35		
	Opportunity Wage			0.0065		
				1.69		
	Time Rate Contract			0.3164		
				1.95		
	Team Contract			-0.4251		
				-2.25		
Barangay	Distance to City	0.0120	0.0121	0.0185	0.0072	0.0272
		4.12	4.16	3.43	1.32	5.18
	New Road Construction	0.6278	0.6311	-0.3670	1.3255	0.8153
		5.38	5.35	-1.26	5.95	4.13
	Urbanization Index	-0.1747	-0.1732	-0.0548	-0.2712	-0.2876
		-4.67	-4.66	-0.75	-3.60	-4.07
Task Dummies	Seedbed Preparation	-0.9051	-0.9028	0.1231	-0.9807	-1.7220
(Plant/Transplant =0)		-4.76	-4.79	0.22	-3.34	-3.32
	Seedbed Care	0.9894	0.9882	0.7497	1.2521	2.2325
		7.68	7.75	2.09	5.11	7.69
	Bundling of Seedlings	1.4760	1.4781	0.6802	2.1588	2.9739
		9.37	9.38	1.34	7.45	8.87
	Pre-Transplant Measure.	1.7004	1.6952	0.8650	2.2173	3.5218
		13.17	13.34	1.65	9.55	12.52
rho			0.2662			
			0.48			
Observations		1482		1482	1558	
Log Likelihood		-1157.12		-1007.26	-1145.82	

NOTE: t-statistics are reported below each coefficient

Table 4 (continued): Planting (Type 2) Tasks - Supervision Demand Equations

Type of Variable	Variable	(1) Probit/Tobit	(2) Bivariate Probit/OLS	(3) Mult. Logit/OLS
	Constant	0.0092	0.8064	2.0477
		1.55	1.64	3.66
Household	No. Male Adults	0.0217	0.0150	0.0302
		0.92	1.42	2.91
	No. Female Adults	-0.0145	-0.0022	-0.0091
		-0.89	-0.22	-0.86
	Sex of Household Head	0.1541	-0.2165	-0.3414
		2.24	-3.72	-4.94
	Education of House. Head	-0.0091	0.0121	0.0060
		-0.62	1.89	0.89
	Age of Household Head	0.0034	0.0015	-0.0015
		1.09	0.72	-0.67
Farm	Farm Size	-0.0004	0.0001	0.0002
		-3.66	0.74	1.98
	Season	0.0260	0.0079	0.0024
		0.51	0.23	0.07
	Gravity Irrigation	-0.0836	-0.0694	-0.2534
		-0.58	-1.03	-2.82
	Pump Irrigation	-0.1055	0.0035	-0.0561
		-0.94	0.06	-0.92
	Location	-0.0301	0.0513	0.0941
		-0.43	1.15	1.97
Labor Market	No. of Hired Workers	0.0074	-0.0066	-0.0052
		2.63	-1.81	-1.55
	Wage	0.0027	-0.0008	-0.0007
		1.75	-1.09	-0.95
	Opportunity Wage of Farmer	0.0023	-0.0008	-0.0006
		1.52	-0.75	-0.67
	Time Rate Contract	0.1349	-0.0230	-0.0140
		1.89	-0.47	-0.31
	Team Contract	-0.2588	-0.1977	-0.2047
		-2.68	-2.89	-3.31
Barangay	Distance to City	-0.4225	0.0032	-0.0013
		-0.57	1.54	-0.56
	New Road Construction	-0.2476	-0.0621	-0.1057
		-1.92	-1.15	-1.94
	Urbanization Index	0.0243	0.0448	0.0779
		0.61	2.05	3.48
Task Dummies	Seedbed Preparation	-0.1612	-0.6025	-0.4150
(Plant/Transplant =0)		-0.47	-3.42	-2.69
	Seedbed Care	0.1736	-0.1789	-0.4939
		0.83	-1.35	-3.27
	Bundling of Seedlings	0.1279	-0.1254	-0.4916
		0.45	-0.81	-2.80
	Pre-Transplant Measurement	0.1323	-0.2017	-0.6705
		0.43	-1.17	-3.12
Sigma (1)		0.5690		
		14.85		
Rho (1)		-0.1638	-0.0238	-0.4735
Lambda (2) & (3)		-0.32	-0.16	-2.51
Observations		614	367	367
R-squared			0.26201	0.27399

NOTE: t-statistics are reported below each coefficient

Table 5: Caring (Type 3) Tasks - Selection Equations

Type of Variable	Variable	(1) Probit/Tobit	(3) Mult. Logit/OLS	
		Hire=1	Hire=1 & Sup=0	Hire=1 & Sup=1
	Constant	-3.8465	-3.2563	-10.8859
		-10.77	-5.25	12.54
Household	No. Male Adults	-0.0658	-0.1268	-0.1407
		-3.43	-3.45	-3.71
	No. Female Adults	0.0952	0.1119	0.0739
		4.63	2.84	1.73
	Sex of Household Head	-0.0598	-0.3124	0.1889
		-0.63	-1.90	0.94
	Education of House. Head	0.0796	0.0767	0.1703
		6.39	3.64	7.33
	Age of Household Head	0.0189	0.0138	0.0600
		4.64	2.00	7.78
Farm	Farm Size	0.0002	0.0005	-0.0003
		2.07	2.68	-0.85
	Season	-0.0364	-0.0681	-0.0570
		-0.51	-0.50	-0.37
	Gravity Irrigation	0.3675	0.6225	0.6591
		3.88	3.75	3.41
	Pump Irrigation	0.4669	0.4593	1.3584
		4.00	2.30	5.98
	Location	0.2273	0.4425	0.2162
		2.15	2.45	1.06
Barangay	Distance to City	0.0063	0.0072	0.0081
		2.34	1.46	1.64
	New Road Construction	0.4712	0.5138	1.1200
		4.64	2.92	5.40
	Urbanization Index	-0.1191	-0.4602	0.0979
		-3.39	-6.60	1.43
Task Dummies	Fertilizing	1.3951	1.2054	3.7765
(Weeding =0)		10.52	5.36	7.81
	Chemical Application	0.6295	0.1612	2.1887
		4.55	0.72	4.50
	Irrigation Control	0.9870	0.7479	2.8259
		7.46	3.51	5.89
Observations		1655	1735	
Log Likelihood		-1269.37	-1256.77	

NOTE: t-statistics are reported below each coefficient

Table 5 (continued): Caring (Type 3) Tasks - Supervision Demand Equations

Type of Variable	Variable	(1) Probit/Tobit	(3) Mult. Logit/OLS
	Constant	-6.8841	5.4131
		-8.78	1.09
Household	No. Male Adults	-0.0535	0.1020
		-1.95	2.12
	No. Female Adults	0.0485	0.0191
		1.51	0.53
	Sex of Household Head	0.1735	-0.1626
		1.08	-0.85
	Education of House. Head	0.0741	-0.0496
		4.22	-0.83
	Age of Household Head	0.0267	-0.0221
		4.17	-0.98
Farm	Farm Size	-0.0001	0.0013
		-0.46	4.72
	Season	-0.0098	0.0959
		-0.10	1.08
	Gravity Irrigation	0.3251	-0.1977
		2.24	-0.91
	Pump Irrigation	0.6314	-0.6656
		3.67	-1.30
	Location	0.0629	-0.0169
		0.39	-0.13
Labor Market	No. of Hired Workers	-0.0071	0.0078
		-0.48	0.85
	Wage	0.0023	-0.0015
		0.63	-0.50
	Opportunity Wage	0.0068	-0.0016
		1.94	-0.59
	Time Rate Contract	-0.0662	-0.1803
		-0.37	-1.00
	Team Contract	0.1464	-0.0556
		0.91	-0.37
Barangay	Distance to City	0.0157	0.0046
		4.08	0.96
	New Road Construction	0.5341	-0.3236
		3.44	-0.76
	Urbanization Index	0.0058	-0.1712
		0.11	-1.86
Task Dummies	Fertilizing	2.3736	-1.4952
(Weeding =0)		6.91	-1.04
	Chemical Application	1.6324	-0.5553
		5.10	-0.59
	Irrigation Control	1.9652	-0.8680
		5.99	-0.78
Sigma (1)		1.2798	
		21.75	
Rho (1)		0.9970	-1.0014
Lambda (3)		100.95	-1.09
Observations		478	254
R-squared			0.23414

Table 6: Harvesting (Type 4) Tasks - Selection Equations

Type of Variable		(1) Probit/Tobit	(2) Bivariate Probit/OLS		(3) Mult. Logit/OLS	
		Hire=1	Hire=1	Sup=1| Hire=1	Hire=1 & Sup=0	Hire=1 & Sup=1
	Constant	0.9043	0.7880	0.9387	-0.9259	-0.1664
		1.77	1.59	2.06	-0.87	-0.18
Household	No. Male Adults	-0.0094	-0.0156	-0.0205	0.0271	-0.0373
		-0.31	-0.53	-0.73	0.46	-0.70
	No. Female Adults	0.0252	0.0650	0.0758	0.0628	0.1545
		0.71	1.87	2.41	0.90	2.44
	Sex of Household Head	-0.4026	-0.2842	0.4412	-1.1864	-0.3693
		-2.33	-1.69	3.13	-3.42	-1.12
	Education of Head	0.0500	0.0446	-0.0811	0.1199	0.0488
		2.51	2.20	-5.97	3.42	1.49
	Age of Household Head	-0.0012	-0.0009	0.0009	0.0054	0.0008
		-0.17	-0.12	0.16	0.46	0.08
Farm	Farm Size	-0.0001	-0.0001	-0.0001	0.0004	-0.0001
		-0.34	-0.70	-0.25	1.53	-0.57
	Season	-0.2212	-0.2166	-0.0570	-0.2539	-0.4118
		-1.92	-1.93	-0.57	-1.09	-1.96
	Gravity Irrigation	0.2460	0.2862	0.1194	0.2543	0.4864
		1.81	2.14	0.98	0.97	2.05
	Pump Irrigation	0.3875	0.4576	0.2084	0.4293	0.8154
		2.19	2.66	1.41	1.20	2.52
	Location	0.2269	0.2430	-0.0029	-0.0750	0.4922
		1.50	1.64	-0.02	-0.26	1.86
Labor Market	No. of Hired Workers			-0.0127		
				-1.41		
	Wage			0.0023		
				2.44		
	Opportunity Wage			0.0050		
				1.35		
	Time Rate Contract			-0.2072		
				-1.69		
	Team Contract			-0.1409		
				-0.95		
Barangay	Distance to City	0.0035	0.0056	0.0021	-0.0035	0.0116
		0.97	1.61	0.48	-0.43	1.58
	New Road Construction	-0.2720	-0.3932	-0.3474	-0.3945	-0.8089
		-1.75	-2.67	-2.69	-1.22	-2.78
	Urbanization Index	-0.0193	-0.0054	-0.0038	0.0768	0.0381
		-0.34	-0.09	-0.09	0.76	0.42
Task Dummies	Threshing	0.2566	0.2947	-0.4209	1.9714	1.4365
(Harvesting =0)		2.12	2.58	-3.31	3.82	3.57
	Harvesting/Threshing				1.0518	1.1541
					2.05	2.94
rho			-0.9796			
			-0.07			
Observations		972		972	1055	
Log Likelihood		-1336.344		-731.7669	-860.781	

Note: t-statistics are reported below each coefficient.

Table 6 (continued): Harvesting (Type 4) Tasks - Supervision Demand Equations

Type of Variable	Variable	(1) Probit/Tobit	(2) Bivariate Probit/OLS	(3) Mult. Logit/OLS
	Constant	0.8617	1.0683	-0.5341
		2.22	2.32	-0.61
Household	No. Male Adults	-0.0120	-0.0087	-0.0279
		-0.50	-0.51	-1.33
	No. Female Adults	0.0379	0.0314	0.0571
		1.54	1.00	1.57
	Sex of Household Head	-0.0093	-0.0920	0.1115
		-0.08	-0.91	0.67
	Education of House. Head	-0.0240	-0.0194	-0.0233
		-1.75	-1.21	-1.50
	Age of Household Head	-0.0044	-0.0054	-0.0069
		-0.86	-1.67	-1.96
Farm	Farm Size	-0.0001	-0.0001	-0.0003
		-0.39	-0.66	-1.91
	Season	-0.1630	-0.1762	-0.2251
		-1.82	-2.28	-2.51
	Gravity Irrigation	0.1660	0.1561	0.1833
		1.63	1.45	1.64
	Pump Irrigation	0.2882	0.2865	0.3585
		2.19	2.10	2.24
	Location	0.1051	0.1113	0.3657
		0.90	1.06	2.04
Labor Market	No. of Hired Workers	-0.0178	-0.0192	-0.0116
		-2.12	-2.72	-1.69
	Wage	0.0004	0.0001	-0.0002
		0.64	0.32	-0.54
	Opportunity Wage	0.0018	0.0012	-0.0004
		0.67	0.53	-0.21
	Time Rate Contract	-0.2136	-0.2178	-0.1382
		-2.10	-2.30	-1.68
	Team Contract	-0.1068	-0.0538	-0.0185
		-1.04	-0.54	-0.20
Barangay	Distance to City	0.0049	0.0049	0.0109
		1.49	1.77	2.38
	New Road Construction	-0.2079	-0.1835	-0.2472
		-1.79	-1.28	-1.64
	Urbanization Index	-0.0223	-0.0328	-0.0349
		-0.56	-1.21	-1.18
Task Dummies	Threshing	-0.3997	-0.4460	0.2632
(Harvesting =0)		-3.46	-4.94	1.25
	Harvesting/Threshing			0.9004
				3.19
Sigma (1)		0.9692		
		83.53		
Rho (1)		0.8888	0.8586	1.6371
lambda (2) & (3)		10.87	1.49	2.15
Observations		852	661	661
R-squared			0.12209	0.13133

NOTE: t-statistics are reported below each coefficient

Table 7: Farm Technical Efficiency Estimates

	Supervision Intensity				Predicted Supervision Intensity			
	Without Barangay		With Barangay		Without Barangay		With Barangay	
	(1)		(2)		(1)		(2)	
	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio	coefficient	t-ratio
Production Frontier								
Constant	-0.8980	-2.40	-0.8086	-2.17	-0.9277	-2.53	-0.8521	-2.29
Land	0.1697	6.60	0.1653	6.11	0.1649	6.60	0.1690	6.13
Labor	0.2859	6.36	0.2822	7.12	0.2829	6.40	0.2764	6.22
Seeds	0.0586	5.14	0.0573	4.91	0.0604	5.35	0.0590	5.09
Fertilizer	0.0376	2.71	0.0400	2.82	0.0385	2.97	0.0399	2.88
Threshers	0.0443	3.42	0.0459	3.50	0.0472	3.66	0.0459	3.57
Tractors	0.0390	3.26	0.0382	3.09	0.0411	3.48	0.0396	3.28
Animals	-0.0090	-1.14	-0.0132	-1.79	-0.0078	-0.97	-0.0109	-1.36
Chemicals	0.0959	4.63	0.0922	4.48	0.1014	5.92	0.0989	4.74
Irrigation - Upland	0.0131	0.07	-0.0764	-0.42	0.0250	0.13	-0.0441	-0.25
Irrigation - Pump	0.0876	1.57	0.0568	0.91	0.0837	1.44	0.0507	0.89
Irrigation - Gravity	0.0394	0.55	0.0292	0.39	0.0405	0.57	0.0358	0.51
Inefficiency equation								
Constant	1.8280	2.13	3.6178	3.08	1.3672	0.75	4.1902	2.53
Sex of Household Head	-1.7415	-1.87	-0.9652	-2.60	-2.1583	-1.51	-1.6780	-1.75
Ownership Dummy	0.7605	1.27	0.2399	1.26	1.0132	1.60	0.4816	1.97
Education of Head	-0.4826	-1.90	-0.2226	-2.86	-0.6155	-1.52	-0.4519	-2.27
Age of Household Head	-0.0554	-2.03	-0.0316	-2.14	-0.0803	-1.06	-0.0610	-1.96
Supervision Intensity	-8.2415	-1.86	-4.3608	-2.37	-1.9154	-1.59	-1.3826	-1.87
Location	-0.9600	-2.03	-0.3785	-1.61	-1.6033	-1.55	-1.0521	-2.06
Distance to City			-0.0371	-2.53			-0.0428	-1.97
Barangay Population			-0.0004	-2.27			-0.0007	-1.73
New Road Construction			-0.5949	-2.02			-0.5481	-1.86
Urbanization Index			0.2212	2.02			0.3517	2.32
sigma-squared	3.8252	1.85	1.7253	3.48	5.2152	1.62	3.3353	2.16
gamma	0.9531	33.51	0.8908	21.24	0.9652	42.51	0.9421	32.18
log likelihood function	-498.24		-495.26		-517.22		-511.51	
LR test for one-sided error	76.05		82.00		69.24		75.64	
number of restrictions	8				8		*	
number of cross-sections	318		318		331		330	
number of time periods	2		2		2		2	
total number of observations	564		564		577		576	