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Labor Supervision and Transaction Costs: Evidence from Bicol Rice Farms

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Abstract

This paper analyzes labor supervision activities reported in a survey of rice farmers in the Bicol region of the Philippines. We present a simple model that relates supervision intensity to transaction costs. The empirical estimates use different institutional conditions to proxy for transaction costs. The results confirm the prediction of the theoretical model that supervision increases with transaction costs. Finally, we estimate a production frontier to show that the negative efficiency effects of transaction costs are partially offset by the positive efficiency effects of supervision.

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Abstract

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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 work effort is not easily verifiable and enforceable, and (2) adverse selection because information on the attributes of heterogeneous workers may not be readily available. Recruiting costs can also arise if communication and transportation networks are weak and labor markets are segmented. Transaction costs will be lower in environments where contracts are easily enforced, information on workers and employers is readily available and labor markets are well connected. The level of transaction costs affects labor and land contract choices and determines the extent to which family labor is advantageous. 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 costs. A number of studies of contract choice support this contention.[1] Other studies have argued, however, that certain transaction costs, such as information costs associated with recruitment, may be lower in close-knit village communities (e.g. Lanjouw). The inherent difficulty of measuring transaction costs, however, has limited the empirical study of 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 quantify the institutional conditions. Our primary concern is to analyze the allocation of time to supervision activities 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 micro-level surveys have not explicitly measured supervision intensities.[2] Several studies have related the demand for supervision to wages and the size of work groups. The relationship between supervision and wages can be either negative or positive. The theoretical reasons for a negative correlation include efficiency wage models that suggest that supervision may be substituted by wage premiums when monitoring is costly (Bulow and Summers). In addition, low supervision and high wages may be both correlated with worker ability that is observable to the employer but unobservable to the econometrician. The arguments in favor of a positive relationship include (1) the compensating differentials theory which argues that workers will tolerate high levels of supervision only if they are duly compensated for the inconvenience; (2) the occupational differences argument that holds that some occupations lend themselves to high levels of shirking, making employers respond with both supervision and efficiency wage premiums; and (3) the substitution argument which says that, if labor and supervision are substitutable in production, a higher relative wage for labor would lead the employer to substitute labor with more supervision. In other words, the employer would attempt to restore the "effective labor" lost due to higher wages by supervising the existing labor more intensively. Empirical studies have found both negative (Groshen and Krueger; Kruse) and positive (Neal) correlations. Supervision also depends on the size of the work group (Taslim, Kruse, Ewing and Payne), 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. Some studies have argued that the well-known inverse farm size-productivity relationship can be explained by supervision problems that "impose an effective restriction on the scale of agricultural production and dampen land productivity on farms which employ substantial amounts of hired labor" (Taslim, p. 55).

Most studies in the literature have focused on the manufacturing sector in developed countries. Among the handful of studies that deal with farm supervision in the developing country context (Taslim, Dong and Dow), none to our knowledge incorporates an explicit measure of supervision.[3] In addition, the literature has not addressed the relationship between institutional conditions (or transaction costs) and supervision. Our unique data allows us to bridge this noticeable gap in the literature. We hypothesize that supervision intensity will be greater in environments with weak market institutions and, all else equal, possibly in larger impersonal markets. We also examine, using the production frontier estimates, to what extent supervision helps to reduce the transaction costs imposed by weak institutional conditions.

In the next section, we develop a simple model of the determination of supervision intensity. After that we perform a comparative static analysis that focuses on the effects of labor market conditions and transaction costs on supervision intensity, and present the results graphically. Then we present the different empirical methodologies we adopt for the empirical analysis. In the following section, we summarize the data. After that we report and discuss the supervision demand estimates. The next section discusses an attempt to address an endogeneity problem. The following section reports our farm efficiency estimates. The final section concludes with policy implications.

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[4], according to the following specification:

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

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 family and hired labor are equally productive, but despite 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.[5] The parameter α is therefore assumed to be a function of village level transaction cost conditions, denoted here by τ. Indirect supervision refers to the fact that family members working together with hired workers increase 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 relative to direct supervision. The latter is naturally assumed to be more effective ($\beta<1$). If family members and hired workers are employed concurrently, the parameter α is restricted by $\alpha+g()<1$, otherwise it 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 opportunity wage rate to be different from the wage paid to hired workers. Family members will work off the farm only if their earnings capacity is higher than that of hired workers. If family members and hired workers are similar in their earnings capacity then the opportunity wage is expected to be lower than the wage that must be paid to hired workers due to transaction costs. In this case it will not be profitable for family members to work off the farm.

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

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

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. The price of farm output is normalized to one.

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.). 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 opportunity 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:

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

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

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. Hence, 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. Eswaran and Kotwal assumed that supervision time is a function of hired labor input rather than a decision variable. In their model it is possible for farm operators to both work and supervise. Our model is more general, allowing for direct and indirect supervision, and conforms better to our data.

Therefore, the decision on whether to work on the farm and indirectly supervise hired workers, or to supervise directly, 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:

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

$$f'(E)[\alpha + g(L^s/L^h)] - w^n L^s/L^h - w^h = 0. \qquad (4b)$$

Solving for $f'(E)$ from (4a) and plugging into (4b), the optimal supervision intensity can be derived from

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

where $s= L^s/L^h$ 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 $g''()<0$.

Comparative Statics and Graphical Illustration

The supervision intensity, s, is a function of w^h, w^n and α. We obtain the comparative static results with respect to each of these variables by implicitly differentiating equation (5). For the hired wage, w^h,

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

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 by increasing the absolute amount of supervision. Here, we have ignored the efficiency wage argument where wages higher than the reservation wage are paid to reduce shirking by increasing the cost of shirking to the worker.

For the off-farm wage, w^n,

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

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

For the transaction cost conditions, τ:

$$\frac{\partial s}{\partial \tau} = \frac{\partial \alpha}{\partial \tau}\frac{\partial s}{\partial \alpha} = \frac{1}{g''(s)[s + \dfrac{w^h}{w^n}]} > 0 \qquad (8)$$

This implies that supervision intensity increases when transaction costs rise. This is because the shirkability of hired labor, reflected by a low α, is assumed to increase with transaction costs. We expect less shirking in areas with well-developed market institutions that provide alternative methods for work effort enforcement. 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 lower. Therefore, weaker institutional conditions lead to a lower α and more supervision.

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. We assume that 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 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 a horizontal line at the opportunity wage. However, we argue that most farmers are time constrained, as reflected by the very low levels of off-farm labor participation (DeSilva). 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 an upper bound of supervision intensity at the labor time endowment level. The shift parameters for curve F are the opportunity wage and the labor time endowment of the employer (as reflected by family size and demographic variables). The observed supervision intensity will be higher if the opportunity wage is low, and if the employer 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 equation on the choice to supervise is specified as a function of hired wages and transaction costs. (2) In our formulation, the major determinant of supervision intensity is the level of transaction costs. This is reflected by assuming that $S_A - S_C > S_C - S_D$ and $S_B - S_D > S_A - S_B$. This assumption 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 transactions 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 Specification

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

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

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

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

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:

$\prod_A pr(L^h \le 0) \times \prod_B pr(L^h > 0 \text{ and } L^s/L^h \le 0) \times$

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

where $\prod_k$ is the product over all the observations belonging to group k, 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:

$\prod_A \Phi(- X^h\gamma/\sigma_u) \times \prod_B \Psi(X^h\gamma/\sigma_u , -X^s\delta/\sigma_v , \rho) \times$

$$\prod_C \phi[(L^s/L^h - X^s\delta)/\sigma_v] \qquad (11)'$$

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)'.[6]

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:

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

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) 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:

$$\prod_A pr(L^h \leq 0) \text{ x } \prod_B pr(L^h > 0 \text{ and } M \leq 0) \text{ x}$$

$$\prod_C pr(L^h > 0 \text{ and } M > 0) cd(L^s/L^h \mid L^h > 0 \text{ and } M > 0) \quad (13)$$

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

$$\Pi_A \Phi(\beta_1' x_1) X \, \Pi_B \Phi_2(\beta_2' x_2, -\beta_1' x_1, -\rho) X$$
$$\Pi_C \Phi_2(\beta_2' x_2, \beta_1' x_1, \rho) \quad (13)'$$

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 - to Spanish data. Both could not reject the independence assumption.

In the third model we utilize, 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 the choice probabilities are:

$$\textbf{Prob}(Y = j) = \frac{e^{\beta_j' x_i}}{1 + \sum_{k=1}^{2} e^{\beta_k' x_i}} \quad \textbf{for } j = 0,1,2 \quad \textbf{and } \beta_0 = 0 \quad (14)$$

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

Data and Descriptive Statistics

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 reported separately for hired labor, family labor, and exchange labor. Exchange labor is ignored because it occurs in less than one percent of the activities. In most activities, either hired labor or family labor is 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 constitute slightly more than one half of all cases (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 includes 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 for hired workers that are employed under a time rate contract, a dummy 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 in this group are a set of barangay-specific variables which proxy for labor market conditions. These are the distance to the nearest poblacion (market), an index of road conditions, an index of urbanization, the distance to the nearest extension service and the barangay population. The first four barangay variables are used as measures of transaction costs. The barangay population has a somewhat different interpretation because, all else equal, a larger market size would involve larger information costs. The third group of explanatory variables includes 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 gender, age and education of the head of household. Table 2 includes definitions of the variables and their descriptive statistics.

Supervision Intensity Estimates

The supervision demand equations were estimated using the probit, bivariate probit and multinomial logit selection equations. Table 3 presents the tobit supervision demand equation from the first model. In this model, the supervision demand function is a tobit equation conditional on the choice to hire labor. Here, the choice to supervise and the extent of supervision are treated as one decision. The farms that do not supervise are treated as zero-censored observations. In the other two models reported in Tables 4 and 5 respectively, the determinants of supervision are allowed to vary across two sequential stages: (1) the choice to supervise, and (2) the supervision intensity, conditional on the choice to supervise. Because the omitted category in the multinomial logit model is not hiring, we also report the relative risk ratios for supervision relative to hiring without supervision.

All estimates are carried out separately for land preparation, planting, caring and harvesting task types. We discuss the effect of four sets of variables on supervision. They are (1) the village level institutional variables, (2) labor market conditions, as reflected by worker and employer wages, (3) farm characteristics, (4) employee characteristics and (5) employer characteristics. Since the hiring decision is not central to this paper, we omit these results from our discussion. The results of the hiring choice equations are reported in the Appendix.

1) Institutional Variables

In the Probit-Tobit model, we see that there is more supervision in relatively less urban barangays. The urbanization effect is significant at 5% level for land preparation and caring tasks, and at 10% level for planting tasks. This result supports our hypothesis that enforcement costs are greater in remote areas. However, we also find some possible evidence in support of the opposite hypothesis. Supervision intensity decreases with distance to markets for harvesting and with distance to extension services for planting.

The bivariate probit and multinomial logit selection models shed more light into understanding this process by separating the choice to supervise from the intensity of supervision. A negative institutional effect on the probability of supervision can be interpreted as the imposition of a fixed cost on supervision. For example, we find that farmers are less likely to supervise hired labor in villages that are distant to extension services (for land preparation), distant from markets (for harvesting) and those with poor roads (for planting). On the other hand, we find a greater likelihood of supervision in more rural barangays (for caring) and in those distant from extension services (for harvesting). It appears that the likelihood of supervision is influenced by both greater enforcement costs and larger fixed costs of supervision in high transaction cost environments. Conditional on the choice to supervise, however, the supervision intensity increases strongly as transaction cost conditions worsen. For example, supervision is more intense for land preparation in barangays that are less urbanized and distant from extension services. For planting, supervision intensity increases with the lower road quality, lower levels of urbanization and greater distance to markets. For harvesting, supervision intensity increases with distance to extension services and decreases with road quality. The only unexpected results are the negative distance to market effect in harvesting and the positive urbanization and road quality effects in caring.[7]

The barangay population variable captures labor market size controlling for other institutional factors. We use this variable to identify whether, all else equal, a large and hence more impersonal market raises enforcement and information costs and thereby increases the demand for supervision. We see that this is indeed the case for land preparation and especially planting and harvesting tasks. The bivariate probit results support our claim that weaker market institutions raise the need for supervision by increasing enforcement costs while a larger market size raises the need for supervision by increasing information costs.[8]

2) Labor Market Conditions

Since supervision time is provided by the employer, his opportunity wage must be negatively related with supervision intensity. The wage of hired workers is positively related to supervision at the farm task level because, as explained earlier, supervision and hired labor are imperfect substitutes in farm production. The efficiency wage theories would, on the other hand, predict the opposite. Because efficiency wages are set individually by employers, we use village level average wages to abstract from efficiency wage consideration and to circumvent endogeneity problems that arise from the joint determination of supervision and individual-level wages (Rebitzer). Our estimates support both hypotheses. A higher average employee wage leads to greater supervision probabilities and intensities while a higher employer wage leads to lower supervision probabilities and intensities. Significant wage effects are found for all four tasks at least in one specification. More importantly, we find significant counter-evidence only in one instance: a higher opportunity wage increases the likelihood of supervision in caring tasks under the multinomial logit specification.

3) Farm Characteristics

We are concerned with two farm characteristics, the farm size and the presence of gravity and pump irrigation. The effect of farm size, controlling for the number of supervisors and supervisees, depends on whether there are spatial scale diseconomies to supervision. That is, as the farm size increases, the supervision intensity required increases because workers are more spatially dispersed. If a farmer has sufficient supervision labor, he or she will supervise more intensively. However, some farmers will find that the net gain from supervision is no longer positive, and would decide to give up supervision altogether. It is quite likely that farm size should, therefore, reduce the probability and increase the intensity of supervision. We find that this is indeed the case for planting and caring tasks, the two types of tasks that tend to be relatively more spatially dispersed.[9] For land preparation and harvesting, increased farm size increases the probability of supervision slightly.

The use of irrigation should increase the productivity of labor and therefore increase the benefits of supervision. As expected, we find that irrigation increases the probability of supervision in all four tasks. However, we also find that supervision intensity decreases with gravity irrigation in planting (both models) and pump irrigation in caring (multinomial logit model) whereas it increases with pump irrigation for harvesting (both models).

4) Employee Characteristics

Although we do not know the age, education and other such demographic characteristics of the workers, we have information on the number of workers (size of work group), the relationship of workers to the employer, the form of wage contract (piece rate vs. time rate) and whether the workers were hired as a team.

In the theoretical discussion, we pointed out the expected effects. Work group size may either increase or decrease supervision intensity depending on scale economies of the technology of supervision, a close personal relationship between worker and employer should reduce the need for supervision, piece rate contracts are likely to be associated with lower supervision and teams should be supervised less by the employer. The latter two effects may be biased in our estimation because labor contract choice is typically simultaneously made with supervision and wage choices. For example, we might find the piece rates are associated with greater supervision because both piece rates and greater supervision are responses to high shirking costs associated with a given worker and/or task. We address some of these issues in the next section.

Our results reveal that the work group size has no effect on supervision intensity. We find, however, that large groups are more likely to be supervised in land preparation and planting tasks, and less likely to be supervised in harvesting. Teams of workers require more intensive supervision in land preparation and less in planting and harvesting. Time rates, counter-intuitively, require less supervision in harvesting. These contract effects are of course likely to be plagued by endogeneity biases.

5) Employer Characteristics

Finally, we consider the labor endowments of the employer households and characteristics of the household head (who we assume to be the farmer). Since supervision itself is a labor intensive activity, it should respond positively to the presence of male adults (potential supervisors) in the household. The effect of female family labor is ambiguous. Even though the presence of female labor will increase the family to hired labor ratio and thereby the scope for supervision (Taslim), there are social considerations that may prevent females from supervising the largely male workforce. We find that households with more female adults are less likely to supervise land preparation and caring tasks, and more likely to supervise harvesting tasks. We find that the male labor endowment effects are on the whole quite weak. The only significant result is that households with more male adults supervise caring tasks more intensively.

Accounting for the Endogeneity of Labor Contract Choice

In the earlier estimates, we treated the choice between time-rate and piece-rate contracts as exogenous to the supervision problem. However, this is clearly not the case, because piece-rate contracts are primarily used as a self-monitoring mechanism when direct supervision by the employer is costly.

The literature on the piece rate vs. time rate choice has distinguished "effort" shirking from "quality" shirking. "Effort" shirking occurs when a worker fails to produce the highest possible amount of output in a given time. "Quality" shirking occurs when a worker fails to produce the best possible quality of output given an observed level of effort. It has been argued that piece rate contracts are designed to minimize "effort" shirking by rewarding the worker with a pay proportionate to observed effort (Stiglitz, Lucas, Roumasset and Uy). "Quality" shirking, on the other hand, can only be mitigated by supervision. The choice between piece and time rate is therefore a function of the magnitudes of quality and effort shirking as well as the marginal effect of supervision on each type of shirking.

Piece rates would also be preferred if workers are heterogeneous and there is a need to screen workers to prevent adverse selection (Stiglitz). However, they are not appropriate if it is difficult to set the appropriate implicit wage. In this case, there is an additional excess burden due to this uncertainty where the implicit wage is not equal to the opportunity wage.

The different enforcement advantages of piece and time rate contracts are seen clearly by how different tasks are assigned to the two contracts. Land preparation, weeding and planting in the Philippines are usually undertaken under "Pakyaw", a form of piece rate where workers are paid according to the land area covered (Roumasset and Uy). Harvesting is largely carried out under the traditional piece rate arrangement while chemical application is almost always under time rate. Quality shirking is easy to monitor in harvesting, but hard to monitor in chemical application. In addition, because harvesting is highly seasonal and requires large amounts of labor, screening is difficult. Both these attributes make harvesting especially amenable to piece rates.

The labor contract and supervision choices are therefore made jointly.[10] Because of the difficulties in identifying the two effects in a system of simultaneous equations, we adopt a modified selection model whereby supervision demand equations are estimated conditional on the choice to supervise as well as the choice of labor contract. Because of the multiplicity of first stage choices, we estimate this model only with the multinomial logit specification.

It could be argued that the choice to hire workers as teams is also endogenous for the same reasons. We limit this extension only to the time-piece rate choice because there is insufficient variation in the team choice to estimate supervision demand equations for each contract-team cell. The decision to treat team choice as exogenous can also be justified by the fact that team formation is usually determined completely by the task-contract choice, i..e.

transplanters, weeders and harvesters form teams whereas teams of seed bundlers or chemical applicators are rarely seen.

In the first stage, we estimate the multinomial logit selection equation with the following five choices: (1) not hired; (2) hired, piece-rate, no supervision; (3) hired, piece-rate, supervision; (4) hired, time-rate, no supervision; and (5) hired, time-rate, supervision. Figure 2 shows that the supervision choices are receptive to contract choice, particularly for caring (type 3) and harvesting (type 4) tasks. The first two columns in each cluster show the mean level of supervision intensity conditional on the choice to supervise, for piece and time rate contracts respectively. The second two columns report the mean probability of supervision of piece and time rates respectively. As expected, the probability of supervision is greater in time rate contracts because the incentive to self-monitor is weaker. The only exception is harvesting. Once the decision to supervise is taken, employers appear to supervise piece rate workers at least as intensively as time rate workers. In fact, for caring (type 3) and harvesting (type 4) tasks, the supervision intensity is considerably greater for piece-rate tasks. This may be explained by the fact that workers sort to tasks by differential productivities, comparative advantages and preferences (Foster and Rosenzweig; Baland, Dreze and Leruth) in such a way that deserves higher supervision intensity for piece-rate workers. In any case, it is clear that the contract choice plays a noticeable role in the supervision decisions.

The selection equations are estimated with not hired (1) as the reference category. Supervision intensity equations are then estimated for categories (3) and (5). Sample selection terms are included as before, based on the multinomial logit probabilities. Because the sample is split into smaller sub-samples, we lose some degrees of freedom. As shown in figure 2, this is particularly a problem for type 2 (planting) and type 3 (caring) tasks that have relatively few piece-rate workers. For example, we have too few observations to estimate a supervision demand equation for type 3 tasks. We also have to omit certain variables, especially the activity dummy variables, in order to make the estimates work.

Table 6 reports the results of the supervision equations by the types of tasks. The multinomial logit coefficients relevant to each supervision equation are also shown, and those related to the other choices are reported in the appendix. The overall fit of the models is generally quite good. Although village level transaction cost conditions consistently have strong effects, their signs leave us with inconclusive evidence about the role of transaction costs on supervision. For piece rate contracts, we find that urbanization lowers supervision demand as expected in planting, and distance to extension increases supervision demand in harvesting. However, we find the opposite effect for quality of roads in land preparation and planting and for distance to market in planting and harvesting. The results, therefore, are quite inconclusive and perhaps even point to a supervision advantage in remote villages. For time rate contracts, the results are less ambiguous. Distance to markets increases supervision intensity in planting, urbanization decreases supervision intensity in land preparation and planting, and distance to extension services increases supervision intensity in caring. As expected, barangay population also increases supervision in planting. However, a few results go against our claim. For caring, quality of roads and urbanization both increase supervision and for harvesting, distance to market decreases supervision while quality of roads increases it.

Overall, the fact that transaction cost conditions are more likely to positively influence supervision in time rate contracts is not surprising because the need for supervision is removed to a large extent by piece rate contracts. Typically, the employer's two choices are piece rate with little supervision and time rate with substantial supervision. The average worker wage increases supervision intensity in time rates for land preparation and caring tasks. This is consistent with what we found earlier. Interestingly, we find negative wage effects for piece rates providing our first piece of evidence against the positive wage-supervision correlation. The opportunity wage of the employer, on the other hand, continues to have a negative effect on supervision intensity.

The Farm Efficiency Estimations[11]

The supervision model implies that institutional conditions play an important role in the determination of the intensity of supervision activities. In this section we estimate the direct and indirect (through supervision) effects of institutional conditions on farm efficiency using a stochastic production function approach (Aigner Lovell and Schmidt; Meeusen and van der Broeck). The production frontier, where Q is output and Z is a vector of observed inputs such as land, labor, fertilizer, seeds, machinery and draft animals, is formulated as follows:

$$\begin{aligned} &Q_i = f(Z_i;\beta)\exp(\varepsilon_i - u_i) \\ &where \quad u_i = |U_i| \quad and \quad U_i \sim N(0,\sigma_u^2) \\ &and \quad \varepsilon_i \sim N(0,\sigma_e^2) \end{aligned} \tag{15}$$

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

$$TE_i = \frac{Q_i}{[f(Z_i;\beta)\exp(\varepsilon)]} = \exp\ (-u_i) \tag{16}$$

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:

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

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, Kalirajan). 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, Ghosh and McGuckin; Reifschneider and Stevenson, Battese and Coelli). 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.

The coefficient a_2 measures 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 would have been biased because supervision intensity is 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.

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 and household level variables such as age, education, family size, 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. Farm efficiency is lower in high transaction cost environments. As we argued earlier, supervision is a mechanism by which some of this efficiency can be restored. Our aim here is to determine whether intensive supervision increases farm efficiency. We estimate the model with and without the supervision variable 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 attempt to estimate the model using the predicted values from the earlier supervision equation as a proxy for supervision intensity.

The first column reports results without controlling for supervision. The institutional variable coefficients here give us a measure of observed transaction costs. The second column presents the efficiency results controlling for supervision. The institutional variable coefficients now give a measure of actual (net of supervision) transaction costs. The third column re-estimates with predicted supervision values. The production function estimates are very similar in all three cases. All inputs except farm animals have a positive sign. 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 estimate 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 in column 1, we find mixed evidence on the correlation between institutional variables and transaction costs. As expected, we find that larger villages have lower transaction costs. We also find that farm efficiency decreases as the distance to market increases, but the effect is not significant. Controlling for market size and distance to market, however, the farms in the more rural villages appear to be more efficient. This may reflect a specialization effect in largely agricultural rural areas compared to semi-urban areas with little organized agricultural activity. This leads us to question whether the urbanization should in fact be interpreted as a measure of strong agricultural markets. Unfortunately, we are not able to include distance to extension and conditions of roads in the efficiency equation because the stochastic frontier estimation is not able to efficiently identify the effects of all five village variables. When all five institutional variables are included, no coefficient of the efficiency equation is significant.

In the second column, we find the expected efficiency effect of supervision. We also find that about a third of the efficiency advantage achieved by more rural villages is accounted for by supervision differences. When the predicted supervision intensity (third column), however, the supervision effect becomes negative. This is quite possibly a biased result due to the omission of distance to extension and road condition in the efficiency equation. Both these variables increased supervision intensity and they are also likely to reduce farm efficiency thereby introducing a negative omitted variable bias in the supervision coefficient.

In addition the supervision effects, we find that farmers who are male, more educated, older and resident in the same village are more efficient. Households that have more male adults and farms that use pump irrigation are also more efficient.

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 region in the Philippines allows us to explicitly estimate supervision intensity 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 on the farm or work in off-farm activities.

We also test the hypothesis that supervision increases farm efficiency. This is done by estimating a farm production frontier with both transaction costs and supervision intensity as determinants of 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 farm efficiency explained by barangay level institutional variables. Because a measure of supervision intensity is included in the efficiency estimates, the index represents 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).

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Notes

[1] See Hayami and Otsuka for a discussion of contract choice and transaction costs.

[2] Some examples of empirical studies are Groshen and Krueger, Kruse, Neal, Ewing and Payne, Dong and Dow, Rebitzer, Taslim.

[3] Kruse and Neal are the only studies that we found that use hours of supervision time even for developed countries.

[4] Khandker specified "effective input" as a nonlinear function of supervision time.

[5] It is quite possible that moral hazard problems would exist even among family members, especially for children of the owner whose consumption level may be independent of their effort in farm work. We, like most other studies of family and hired labor, assume that the

intra-family incentive schemes function well compared to incentives faced by wage laborers.

[6] Essentially, this model is a variant of a double-hurdle model with sample separation, but it is different from the models of Jones (1989) and Lacroix and Prechette in the fact that the second hurdle comes into effect only if the first hurdle is passed.

[7] The institutional effects are significant in caring only under the multinomial logit specification. This is not surprising because an overwhelming proportion of caring tasks are undertaken by family and long-term workers thereby leaving very little variation in supervision intensity and less predictive power.

[8] A few coefficients are inconsistent with this result. For example, supervision decreases with distance to markets in harvesting and with distance to extension services in planting.

[9] Negative probability effect is present only in the bivariate probit specification.

[10] Alston, Datta and Nugent studied the simultaneous determination of direct supervision and contractual choice in the presence of transactions costs in American plantation farms.

[11] The discussion in this section borrows heavily from DeSilva.

Table 1. Number of Cases, Cases with Hired Workers, and Incidence of Supervision

Type of activity		Activity		All cases	Cases with hired workers		Cases with supervision	
No.	Name	No.	Name	No.	No.	Frac.	No.	Frac.
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

Variable Name	Obs.	Mean	St. Dev.	Definition
Supervision Intensity	3295	0.4222	0.6223	Direct supervision hours divided by hours of hired work
Hire (Dummy)	6014	0.5478	0.4977	Dummy for the existence of hired labor
Number of Workers	3295	4.2822	6.0247	Number of hired workers
Relationship (Dummy)	3135	0.8264	0.3788	Worker has a strong personal bond with employer
Average Worker Wage	3294	76.3024	66.5203	Daily wage of hired workers (peso)
Employer Opportunity Wage	5693	52.2610	16.9811	Daily off-farm labor earnings of family members, peso
Time Rate Contract (Dummy)	3166	0.6317	0.4824	Dummy for a time-rate labor contract
Team Contract (Dummy)	6014	0.0749	0.2634	Dummy for hiring workers through a contractor
Farm Size	6014	210.56	536.08	Land area of the farm (hectares/100)
Male Adults	6014	3.8175	2.1217	Number of adult male household members
Female Adults	6014	3.8195	1.7787	Number of adult female household members
Rainy Season (Dummy)	6104	0.5357	0.4987	Dummy for the rainy season
Male Employer	6014	0.7896	0.4075	Dummy for a male head of household
Education of Employer	6014	6.8540	3.6866	Years of schooling of the head of household
Age of Employer	6014	58.1238	11.1213	Age of household head
Gravity Irrigation (Dummy)	6014	0.4062	0.4911	Dummy for using gravity irrigation
Pump Irrigation (Dummy)	6014	0.2268	0.4188	Dummy for using pump irrigation
Local Resident (Dummy)	6014	0.7911	0.4065	Plot located in the same barangay as the residence of the household head
Distance to Poblacion	6104	5.3152	5.0728	Distance from barangay to the nearest Poblacion (market), km
Barangay Population	6104	2406.5	1481.2	Population of the barangay
Road Conditions Index	5769	1.9459	0.8786	Index of Road Conditions (1=worst, 5=best)
Urbanization Index	6005	2.3925	1.2976	Index of Urbanization (1=lowest, 5=highest)
Distance to Extension Service	6016	2.2040	2.6816	Distance from barangay to the nearest extension service, km

Table 3: Probit/Tobit Model - Supervision Equations

	Land Prep.	Planting	Caring	Harvesting
Constant	-0.836**	-0.352	-2.580	0.216
	{0.335}	{0.806}	{3.862}	{0.441}
Number of Workers	0.061**	0.012*	0.002	-0.015*
	{0.024}	{0.006}	{0.018}	{0.008}
Team Contract	0.126	-0.356**	0.191	-0.211**
	{0.087}	{0.109}	{0.181}	{0.107}
Time Rate Contract	0.005	0.048	0.005	0.003
	{0.075}	{0.077}	{0.256}	{0.055}
Relationship Dummy	0.006	0.042	0.005	0.004
	{0.073}	{0.076}	{0.207}	{0.109}
Male Adults	0.008	0.014	0.042	-0.005
	{0.015}	{0.034}	{0.104}	{0.022}
Female Adults	-0.003	-0.005	-0.067	0.043*
	{0.019}	{0.018}	{0.149}	{0.024}
Average Worker Wage	0.005**	0.005*	0.008	0.003
	{0.002}	{0.003}	{0.024}	{0.003}
Employer Opportunity Wage	-0.005**	-0.001	0.004	-0.003
	{0.002}	{0.002}	{0.013}	{0.003}
Male Employer	0.177**	0.219**	0.459*	0.024
	{0.084}	{0.075}	{0.267}	{0.113}
Education of Employer	0.000	-0.019	0.014	-0.032**
	{0.011}	{0.026}	{0.111}	{0.013}
Age of Employer	0.007*	0.006	0.021	-0.002
	{0.004}	{0.005}	{0.038}	{0.005}
Farm Size	-0.008	-0.035**	0.004	-0.001
	{0.009}	{0.012}	{0.030}	{0.012}
Rainy Season	-0.028	0.022	0.040	-0.132
	{0.059}	{0.054}	{0.140}	{0.083}
Gravity Irrigation Dummy	-0.081	-0.029	0.062	0.165
	{0.086}	{0.147}	{0.199}	{0.113}
Pump Irrigation Dummy	0.085	0.043	0.291	0.326**
	{0.094}	{0.154}	{0.469}	{0.126}
Local Resident	0.098	-0.106	-0.215	0.131
	{0.093}	{0.098}	{0.306}	{0.108}
Distance to Poblacion	-0.001	0.000	-0.010	-0.025**
	{0.007}	{0.008}	{0.021}	{0.011}
Barangay Population	-0.005	-0.049	0.007	-0.020
	{0.028}	{0.032}	{0.128}	{0.043}
Distance to Extension Service	-0.018	-0.027*	0.047	0.032
	{0.016}	{0.016}	{0.140}	{0.020}
Urbanization Index	-0.067**	-0.056*	-0.185**	-0.021
	{0.030}	{0.032}	{0.085}	{0.044}
Road Conditions Index	0.023	0.058	0.099	-0.028
	{0.043}	{0.038}	{0.233}	{0.057}
Sigma	0.791**	0.577**	1.009**	0.898**
	{0.018}	{0.043}	{0.139}	{0.011}
Rho	0.785**	0.073	-0.089	0.895**
	{0.088}	{1.034}	{2.250}	{0.079}
Observations	1331	1479	1590	981

* Coefficient significant at 10%; ** Coefficient significant at 5%. Same in all tables.

Table 4: Bivariate Probit Selection - Supervision Equations

	Land Prep		Planting		Caring		Harvesting	
Variable	Choice	Demand	Choice	Demand	Choice	Demand	Choice	Demand
Constant	-1.049*	-0.111	-1.733**	0.539**	-3.769**	-0.286	0.546	-0.239
	{0.587}	{0.363}	{0.818}	{0.196}	{0.636}	{0.563}	{0.576}	{0.445}
Number of Workers	0.107**	0.010	0.045**	0.000	0.007	0.006	-0.022**	-0.001
	{0.042}	{0.016}	{0.018}	{0.068}	{0.010}	{0.008}	{0.009}	{0.007}
Team Contract	-0.007	0.228**	-0.528*	-0.208**	0.212	-0.098	-0.130	-0.189**
	{0.132}	{0.070}	{0.271}	{0.012}	{0.183}	{0.166}	{0.153}	{0.094}
Time Rate Contract	0.105	-0.062	0.194	-0.007	0.031	-0.045	-0.177	-0.212**
	{0.108}	{0.065}	{0.146}	{0.086}	{0.183}	{0.187}	{0.128}	{0.080}
Relationship Dummy	0.018	-0.034	0.083	-0.070	-0.144	0.191	-0.253*	0.315**
	{0.104}	{0.075}	{0.157}	{0.046}	{0.161}	{0.147}	{0.148}	{0.097}
Male Adults	0.006	0.008	-0.010	0.005	-0.035	0.077**	-0.010	-0.004
	{0.027}	{0.012}	{0.056}	{0.009}	{0.028}	{0.025}	{0.029}	{0.016}
Female Adults	-0.006	-0.022	0.032	-0.014	-0.011	0.024	0.079**	0.017
	{0.031}	{0.015}	{0.033}	{0.010}	{0.045}	{0.031}	{0.034}	{0.019}
Average Worker Wage	0.005	0.004**	0.016*	0.001*	-0.004	0.008*	0.011**	-0.001
	{0.003}	{0.001}	{0.009}	{0.001}	{0.006}	{0.005}	{0.004}	{0.001}
Employer Opportunity Wage	-0.006**	-0.001	0.000	-0.003**	0.002	-0.006**	0.005	-0.009**
	{0.003}	{0.002}	{0.003}	{0.001}	{0.004}	{0.003}	{0.004}	{0.003}
Male Employer	0.276**	0.090	0.681**	-0.244**	0.333*	0.016	0.505**	-0.313**
	{0.140}	{0.071}	{0.269}	{0.052}	{0.198}	{0.151}	{0.145}	{0.092}
Education of Employer	0.029	-0.040**	-0.019	-0.001	0.054**	-0.009	-0.091**	0.026**
	{0.019}	{0.008}	{0.051}	{0.007}	{0.019}	{0.017}	{0.014}	{0.013}
Age of Employer	0.016**	-0.004	0.011*	0.000	0.035**	-0.002	0.001	0.000
	{0.006}	{0.003}	{0.007}	{0.002}	{0.006}	{0.006}	{0.006}	{0.003}
Farm Size	-0.010	-0.006	-0.067*	0.014*	-0.054**	-0.133**	-0.008	0.002
	{0.014}	{0.009}	{0.039}	{0.008}	{0.019}	{0.021}	{0.022}	{0.009}
Rainy Season	-0.081	0.035	0.045	-0.003	0.016	0.056	-0.032	-0.194**
	{0.085}	{0.047}	{0.109}	{0.034}	{0.099}	{0.094}	{0.102}	{0.066}
Gravity Irrigation Dummy	-0.172	0.040	0.299	-0.138**	0.178	0.019	0.313**	0.117
	{0.154}	{0.070}	{0.200}	{0.051}	{0.149}	{0.146}	{0.141}	{0.092}
Pump Irrigation Dummy	0.127	-0.041	0.193	0.062	0.598**	-0.129	0.339**	0.353**
	{0.173}	{0.071}	{0.275}	{0.059}	{0.171}	{0.147}	{0.168}	{0.109}
Local Resident	0.112	0.113*	-0.286*	0.008	-0.108	-0.105	0.028	0.278**
	{0.127}	{0.066}	{0.146}	{0.044}	{0.170}	{0.142}	{0.151}	{0.107}
Distance to Poblacion	0.002	-0.005	-0.019	0.016**	-0.014	-0.015	-0.013	-0.032**
	{0.010}	{0.006}	{0.015}	{0.005}	{0.014}	{0.013}	{0.013}	{0.009}
Barangay Population	-0.058	0.012	-0.163*	0.043**	0.018	0.088	-0.181**	0.094**
	{0.004}	{0.026}	{0.088}	{0.016}	{0.056}	{0.055}	{0.049}	{0.038}
Distance to Extension	-0.068**	0.037**	-0.020	-0.018*	-0.031	0.047	0.026	0.044**
	{0.024}	{0.013}	{0.033}	{0.009}	{0.030}	{0.030}	{0.024}	{0.016}
Urbanization Index	-0.005	-0.078**	0.008	-0.068**	-0.210**	0.024	0.047	-0.066*
	{0.050}	{0.025}	{0.058}	{0.016}	{0.074}	{0.056}	{0.055}	{0.034}
Road Conditions Index	0.046	0.021	0.237**	-0.085**	-0.093	0.059	0.098	-0.148**
	{0.075}	{0.035}	{0.110}	{0.025}	{0.081}	{0.073}	{0.071}	{0.052}
Rho/Lambda	0.756**	0.111**	0.580	-0.006	0.874**	0.021	-0.990	2.842**
	{0.275}	{0.049}	{0.653}	{0.068}	{0.160}	{0.037}	{0.758}	{0.758}
Observations	1306	499	1430	354	1548	242	921	620
Log likelihood	-1178.79		-1173.30		-1081.89		-692.87	
R-square		0.191		0.315		0.256		0.166

Table 5a: Multinomial Logit Selection - Supervision Equations

	Land Prep		Planting		Caring		Harvesting	
Variable	Choice	Demand	Choice	Demand	Choice	Demand	Choice	Demand
Constant	-2.680**	0.989**	-2.386	1.004*	-5.656**	14.083**	-0.491	-0.239
	{0.715}	{0.514}	{0.639}	{0.579}	{0.794}	{3.791}	{1.147}	{0.779}
Number of Workers		0.013		-0.002		0.001		-0.009
		{0.016}		{0.003}		{0.008}		{0.007}
Team Contract		0.240**		-0.216**		-0.017		-0.153
		{0.071}		{0.065}		{0.162}		{0.095}
Time Rate Contract		-0.074		-0.012		-0.106		-0.135*
		{0.065}		{0.046}		{0.181}		{0.078}
Relationship Dummy		-0.113*		-0.073		0.039		0.108
		{0.066}		{0.047}		{0.145}		{0.079}
Male Adults	-0.076**	0.004	-0.124**	0.012	-0.077**	0.145**	-0.073	-0.006
	{0.038}	{0.012}	{0.035}	{0.012}	{0.038}	{0.029}	{0.058}	{0.018}
Female Adults	0.094**	-0.013	0.031	-0.016	0.096**	-0.058	0.095	0.043
	{0.045}	{0.014}	{0.040}	{0.011}	{0.043}	{0.036}	{0.068}	{0.030}
Average Worker Wage	0.001	0.003**	0.003	0.000	-0.020**	0.031**	0.009	0.003
	{0.003}	{0.001}	{0.003}	{0.001}	{0.006}	{0.007}	{0.008}	{0.003}
Employer Opportunity Wage	-0.012**	-0.001	0.001	-0.003**	-0.001	-0.013**	-0.021**	-0.005*
	{0.005}	{0.002}	{0.004}	{0.001}	{0.005}	{0.003}	{0.007}	{0.003}
Male Employer	-0.084	0.052	0.543**	-0.327**	-0.072	-0.077	-0.358	0.027
	{0.204}	{0.078}	{0.190}	{0.111}	{0.208}	{0.148}	{0.354}	{0.143}
Education of Employer	0.151**	-0.041**	0.093**	-0.004	0.157**	-0.257**	0.046	-0.023
	{0.025}	{0.011}	{0.024}	{0.007}	{0.023}	{0.067}	{0.035}	{0.017}
Age of Employer	0.051**	-0.007	0.023**	-0.002	0.061**	-0.103**	0.013	-0.003
	{0.008}	{0.004}	{0.007}	{0.003}	{0.008}	{0.027}	{0.011}	{0.003}
Farm Size	0.000	0.000	0.000	0.000**	0.000	0.003**	0.000	0.000
	{0.027}	{0.009}	{0.025}	{0.011}	{0.029}	{0.037}	{0.039}	{0.010}
Rainy Season	-0.137	0.039	-0.012	-0.005	-0.036	0.070	-0.406*	-0.155**
	{0.144}	{0.048}	{0.138}	{0.034}	{0.152}	{0.090}	{0.215}	{0.072}
Gravity Irrigation Dummy	0.115	0.051	0.826**	-0.221**	0.126	-0.123	0.509*	0.192
	{0.193}	{0.071}	{0.180}	{0.110}	{0.212}	{0.146}	{0.279}	{0.151}
Pump Irrigation Dummy	0.734**	-0.038	0.612**	0.006	0.816**	-1.514**	0.979**	0.410**
	{0.206}	{0.082}	{0.220}	{0.088}	{0.212}	{0.384}	{0.332}	{0.203}
Local Resident	-0.087	0.098	-0.425**	0.055	-0.029	0.029	0.629**	0.235
	{0.200}	{0.069}	{0.175}	{0.070}	{0.203}	{0.142}	{0.272}	{0.147}
Distance to Poblacion	0.007	-0.005	-0.026	0.020**	-0.012	0.004	-0.047**	-0.034**
	{0.017}	{0.006}	{0.019}	{0.007}	{0.019}	{0.014}	{0.023}	{0.014}
Barangay Population	0.000	0.000	0.000	0.000**	0.000	0.000	0.000	0.000
	{0.078}	{0.027}	{0.068}	{0.024}	{0.075}	{0.053}	{0.131}	{0.040}
Distance to Extension	-0.167**	0.044**	-0.024	-0.014	-0.144**	0.227**	0.089	0.046**
	{0.035}	{0.019}	{0.035}	{0.010}	{0.039}	{0.053}	{0.053}	{0.023}
Urbanization Index	-0.175**	-0.080**	0.041	-0.067**	-0.277**	0.600**	-0.122	-0.047
	{0.075}	{0.027}	{0.065}	{0.016}	{0.078}	{0.158}	{0.109}	{0.036}
Road Conditions Index	-0.240**	0.014	0.180*	-0.113**	-0.242**	0.335**	-0.335**	-0.035
	{0.093}	{0.035}	{0.095}	{0.042}	{0.101}	{0.101}	{0.142}	{0.041}
Lambda		-0.323		-0.267		-3.877**		1.139*
		{0.296}		{0.313}		{1.016}		{0.663}
Log likelihood	-1220.1		-1269.5		-1168.5		-795.6	
R-square		0.184		0.316		0.302		0.151
Observations	1331	499	1479	354	1590	242	981	620

Table 5b: Multinomial Logit Model - Relative Risk Ratios for Supervision Choice

	Land Prep	Planting	Caring	Harvesting
Male Adults	1.028	1.066	1.073	0.971
Female Adults	0.916	1.031	0.884	1.116
Average Worker Wage	1.008	1.023	1.013	1.014
Employer Opportunity Wage	0.993	1.002	1.026	0.996
Male Employer	1.660	3.092	1.408	2.350
Education of Employer	1.021	0.954	1.070	0.900
Age of Employer	1.016	1.012	1.043	0.999
Farm Size	0.999	0.999	0.999	1.000
Rainy Season	0.964	1.077	1.069	0.905
Gravity Irrigation Dummy	0.724	1.801	1.212	1.898
Pump Irrigation Dummy	0.969	1.192	2.095	2.257
Local Resident	1.491	0.686	0.527	1.529
Distance to Poblacion	0.999	0.965	0.999	0.951
Barangay Population	1.000	1.000	1.000	1.000
Distance to Extension Service	0.920	0.959	0.994	1.087
Urbanization Index	0.986	0.912	0.619	0.979
Road Conditions Index	1.209	1.438	0.905	1.124

Note: The risk ratios are relative to the hiring without supervision.

Table 6a: Supervision Estimates: Multinomial Logit Selection - Piece Rates

	Land Prep		Planting		Caring	Harvesting	
	Choice	Demand	Choice	Demand	Choice	Choice	Demand
Constant	-5.139**	4.167**	-4.653**	-0.741	-5.385**	-0.357	0.036
	{1.205}	{1.870}	{1.167}	{1.446}	{2.618}	{1.193}	{0.666}
Lambda		-1.353*		0.122			0.985*
		{0.703}		{0.540}			{0.575}
Number of Workers		0.074		-0.005			-0.009
		{0.048}		{0.007}			{0.008}
Relationship Dummy		0.304**		0.272**			0.117
		{0.110}		{0.089}			{0.095}
Team Contract		0.414**		-0.410**			-0.109
		{0.150}		{0.082}			{0.120}
Farm Size	-0.047	0.011	0.009	-0.016	-0.324	-0.005	-0.017
	{0.059}	{0.039}	{0.043}	{0.014}	{0.294}	{0.040}	{0.014}
Male Adults	0.104	-0.140**	-0.129*	0.081**	-0.009	-0.068	-0.001
	{0.066}	{0.053}	{0.068}	{0.021}	{0.116}	{0.059}	{0.022}
Female Adults	0.223**	-0.076*	-0.105	0.053*	-0.364*	0.121*	0.041
	{0.077}	{0.046}	{0.083}	{0.029}	{0.195}	{0.071}	{0.035}
Rainy Season	-0.288	0.139	0.101	0.007	-0.011	-0.446**	-0.175**
	{0.249}	{0.092}	{0.259}	{0.048}	{0.477}	{0.221}	{0.085}
Average Wage	0.004	-0.007*	0.016**	0.001	-0.003	0.011	0.003
	{0.005}	{0.004}	{0.004}	{0.005}	{0.015}	{0.008}	{0.003}
Opportunity Wage	0.012*	-0.011	0.008	-0.001	-0.026*	-0.028	-0.009**
	{0.007}	{0.007}	{0.008}	{0.002}	{0.015}	{0.007}	{0.004}
Male Employer	-0.922**	0.662**	0.658	0.179	-0.230	-0.280**	-0.028
	{0.331}	{0.235}	{0.419}	{0.194}	{0.683}	{0.364}	{0.151}
Education	0.208**	-0.097**	0.079*	0.004	0.228**	0.044	-0.025
	{0.039}	{0.032}	{0.042}	{0.011}	{0.074}	{0.036}	{0.019}
Age of Employer	0.018	0.018**	0.013	0.008**	0.069**	0.006	-0.007*
	{0.015}	{0.008}	{0.013}	{0.003}	{0.025}	{0.012}	{0.004}
Gravity Irrigation	0.172	0.239	0.465	-0.098	-0.563	0.538*	0.189
	{0.355}	{0.163}	{0.349}	{0.108}	{0.696}	{0.290}	{0.152}
Pump Irrigation	0.980**	-0.154	0.668*	0.000	-0.726	1.130**	0.486**
	{0.347}	{0.215}	{0.369}	{0.131}	{0.757}	{0.340}	{0.220}
Local Resident	0.199	-0.214	-0.441	-0.074	1.090	0.690**	0.241
	{0.366}	{0.218}	{0.319}	{0.106}	{0.803}	{0.280}	{0.151}
Distance to Poblacion	0.001	0.011	-0.064	-0.047**	-0.046	-0.065**	-0.038**
	{0.032}	{0.011}	{0.042}	{0.016}	{0.087}	{0.025}	{0.016}
Road Conditions	-0.416**	0.266**	-0.111	0.108**	0.309	-0.417**	-0.093
	{0.171}	{0.089}	{0.179}	{0.052}	{0.429}	{0.146}	{0.060}
Population	0.025	-0.009	-0.095	0.000	0.089	0.235	0.021
	{0.122}	{0.064}	{0.135}	{0.051}	{0.241}	{0.135}	{0.041}
Urbanization	-0.092	-0.024	0.078	-0.096**	0.294	-0.043	0.014
	{0.132}	{0.053}	{0.129}	{0.031}	{0.313}	{0.114}	{0.047}
Distance to Extension	-0.153**	0.028	0.106	0.036	-0.014	0.109**	0.053**
	{0.061}	{0.037}	{0.063}	{0.026}	{0.131}	{0.055}	{0.027}
Observations	1323	87	1466	76	1562	972	489
Log Likelihood	-1555		-1507.0		-1186.4	-1163.0	
R-sqare		0.571		0.823			0.139

Table 6b: Supervision Estimates: Multinomial Logit Selection - Time Rates

	Land Prep		Planting		Caring		Harvesting	
	Choice	Demand	Choice	Demand	Choice	Demand	Choice	Demand
Constant	-2.653**	0.652	-2.026**	0.959	-5.805**	9.999**	-3.109**	-0.491
	{0.742}	{0.571}	{0.702}	{0.701}	{0.823}	{3.260}	{1.458}	{1.553}
Lambda		0.011		-0.023		-2.673**		0.427
		{0.336}		{0.401}		{0.855}		{0.616}
Number of Workers		0.012		-0.002		-0.002		0.004
		{0.018}		{0.003}		{0.009}		{0.010}
Relationship Dummy		-0.235		-0.051		0.066		-0.022
		{0.079}		{0.053}		{0.154}		{0.089}
Team Contract		0.155*		-0.186**		-0.139		0.057
		{0.084}		{0.081}		{0.192}		{0.126}
Farm Size	0.050	0.000	-0.026	0.032	-0.021	0.199	0.043	0.003
	{0.028}	{0.010}	{0.028}	{0.013}	{0.029}	{0.029}	{0.044}	{0.012}
Male Adults	-0.103**	-0.005	-0.136**	-0.007**	-0.085**	0.130**	-0.104	-0.016
	{0.040}	{0.017}	{0.037}	{0.017}	{0.040}	{0.032}	{0.071}	{0.017}
Female Adults	0.073	-0.004	0.057	-0.037**	0.124**	-0.069	0.029	-0.002
	{0.047}	{0.018}	{0.043}	{0.015}	{0.044}	{0.043}	{0.084}	{0.019}
Rainy Season	-0.115	0.033	-0.016	0.004	-0.005	0.051	-0.313	-0.017
	{0.150}	{0.054}	{0.148}	{0.038}	{0.157}	{0.098}	{0.266}	{0.050}
Average Wage	0.001	0.004**	-0.007	-0.002*	-0.023**	0.027**	-0.004	0.008
	{0.003}	{0.001}	{0.004}	{0.002}	{0.006}	{0.008}	{0.011}	{0.005}
Opportunity Wage	-0.017**	-0.003	0.000	-0.003**	0.002	-0.014**	0.001	-0.001
	{0.005}	{0.003}	{0.005}	{0.001}	{0.005}	{0.004}	{0.008}	{0.006}
Male Operator	0.095	-0.021	0.391*	-0.261**	-0.120	-0.091	-0.614	0.159
	{0.216}	{0.111}	{0.200}	{0.105}	{0.214}	{0.165}	{0.417}	{0.110}
Education of Operator	0.136**	-0.033**	0.097**	-0.002	0.151**	-0.171**	0.046	-0.024*
	{0.025}	{0.010}	{0.025}	{0.009}	{0.024}	{0.054}	{0.043}	{0.013}
Age of Operator	0.056**	-0.003	0.027**	0.000	0.060**	-0.070**	0.035**	0.000
	{0.008}	{0.006}	{0.007}	{0.004}	{0.008}	{0.023}	{0.014}	{0.008}
Gravity Irrigation	0.085	0.005	0.862**	-0.224	0.229	-0.168	0.354	0.088
	{0.201}	{0.080}	{0.195}	{0.143}	{0.218}	{0.169}	{0.348}	{0.084}
Pump Irrigation	0.698**	-0.025	0.599**	0.045	0.956**	-1.186**	0.491	-0.149
	{0.213}	{0.088}	{0.245}	{0.100}	{0.219}	{0.374}	{0.414}	{0.120}
Local Resident	-0.140	0.102	-0.382**	-0.036	-0.105	0.008	0.586	-0.091
	{0.207}	{0.077}	{0.190}	{0.078}	{0.207}	{0.159}	{0.360}	{0.095}
Distance to Poblacion	0.010	-0.003	-0.021	0.026**	-0.010	-0.004	-0.026	-0.013*
	{0.018}	{0.007}	{0.020}	{0.007}	{0.019}	{0.014}	{0.028}	{0.007}
Road Conditions	-0.186*	0.004	0.257**	-0.079	-0.271**	0.265**	-0.147	0.117*
	{0.097}	{0.042}	{0.104}	{0.063}	{0.104}	{0.104}	{0.173}	{0.062}
Population	0.005	0.002	-0.002	0.025	0.083	0.002	-0.023	0.000
	{0.080}	{0.030}	{0.073}	{0.000}	{0.077}	{0.057}	{0.168}	{0.079}
Urbanization	-0.169**	-0.099**	-0.002	-0.078**	-0.319**	0.477**	-0.413**	-0.019
	{0.078}	{0.031}	{0.070}	{0.021}	{0.080}	{0.158}	{0.135}	{0.104}
Distance to Extension	-0.175**	0.029	-0.084**	-0.021	-0.155**	0.163**	-0.003	0.039
	{0.037}	{0.022}	{0.040}	{0.020}	{0.041}	{0.051}	{0.068}	{0.029}
Observations	1323	412	1466	278	1562	223	972	131
Log Likelihood	-1555		-1507.0		-1186.4		-1163.0	
R-sqare		0.195		0.349		0.283		0.602

Table 7: Farm Production Function: Frontier Estimates

	Without Supervision		Actual Supervision		Predicted Supervision	
Variable	Coeff	{Std. Err.}	Coeff	{Std. Err.}	Coeff	{Std. Err.}
Production Equation						
Constant	-0.912**	{0.380}	-0.962**	{0.383}	-0.978**	{0.382}
Land	0.143**	{0.031}	0.139**	{0.028}	0.143**	{0.019}
Labor	0.290**	{0.045}	0.299**	{0.046}	0.298**	{0.044}
Seeds	0.053**	{0.012}	0.052**	{0.012}	0.052**	{0.012}
Fertilizer	0.037**	{0.014}	0.036**	{0.014}	0.038**	{0.014}
Threshers	0.055**	{0.014}	0.056**	{0.013}	0.057**	{0.013}
Tractors	0.026**	{0.012}	0.025**	{0.013}	0.024**	{0.012}
Animals	-0.010	{0.008}	-0.012	{0.008}	-0.012	{0.008}
Chemicals	0.123**	{0.022}	0.124**	{0.022}	0.123**	{0.022}
Efficiency Equation						
Constant	-4.657**	{1.345}	-4.710**	{-1.301}	-3.855**	{1.293}
Season	0.293	{0.193}	0.258	{0.180}	0.262	{0.189}
Gravity Irrigation	0.328	{0.247}	0.429	{0.266}	0.300	{0.238}
Pump Irrigation	1.528**	{0.662}	1.437**	{0.585}	1.359**	{0.580}
Sex of Head	1.118**	{0.432}	0.869**	{0.342}	1.038**	{0.408}
Educ of Head	0.388**	{0.149}	0.331**	{0.108}	0.343**	{0.129}
Age of Head	0.034**	{0.014}	0.029**	{0.012}	0.027**	{0.013}
Resident	0.679**	{0.260}	0.483**	{0.220}	0.695**	{0.265}
Male Adults	0.232*	{0.128}	0.193*	{0.103}	0.221*	{0.127}
Female Adults	-0.135	{0.101}	-0.094	{0.079}	-0.116	{0.094}
Barangay Population	0.475*	{0.273}	0.499*	{0.256}	0.486*	{0.280}
Dist to Poblacion	-0.033	{0.022}	-0.022	{0.020}	-0.030	{0.020}
Urbanization	-0.381**	{0.176}	-0.267**	{0.133}	-0.345**	{0.161}
Supervision			1.702**	{0.708}	-0.327*	{0.180}
Sigma-Squared	2.091**	{0.654}	1.802**	{0.453}	1.918**	{0.521}
Gamma	0.902**	{0.034}	0.887**	{0.031}	0.896**	{0.028}
Log L	-467.304		-465.747		-467.168	
LR Test	80.230		83.343		80.501	
Observations	527		527		527	

Note: The null hypothesis in the LR test is that OLS is sufficient. See Battese and Coelli for the definitions of Sigma-Squared and Gamma.

Appendix

Table A1: Hiring Choice Equations

	Probit/Tobit Model				Bivariate Probit Selection Model				Multinomial Logit Selection			
Variable	Prep	Planting	Caring	Harvest	Prep	Planting	Caring	Harvest	Prep	Planting	Caring	Harvest
Constant	-1.26**	-0.77**	-1.20**	0.510	-1.22**	-0.93**	-1.37**	0.290	-2.84**	-1.312*	0.242	-0.306
	{0.405}	{0.329}	{0.374}	{0.691}	{0.414}	{0.334}	{0.383}	{0.697}	{0.765}	{0.708}	{0.798}	{1.253}
Male Adults	-0.06**	-0.08**	-0.06**	-0.029	-0.06**	-0.086*	-0.07**	-0.027	-0.10**	-0.18**	-0.14**	-0.044
	{0.023}	{0.018}	{0.020}	{0.034}	{0.023}	{0.018}	{0.021}	{0.033}	{0.043}	{0.040}	{0.043}	{0.064}
Female Adults	0.089**	0.012	0.092**	-0.018	0.080**	0.015	0.099**	0.034	0.181**	0.001	0.219**	-0.014
	{0.027}	{0.021}	{0.022}	{0.039}	{0.028}	{0.022}	{0.023}	{0.039}	{0.048}	{0.042}	{0.043}	{0.075}
Average Wage	-0.001	-0.002	-0.02**	0.001	-0.002	-0.002	-0.02**	0.002	-0.007*	-0.02**	-0.03**	-0.005
	{0.002}	{0.002}	{0.003}	{0.006}	{0.002}	{0.002}	{0.003}	{0.006}	{0.004}	{0.006}	{0.006}	{0.009}
Opportunity Wage	-0.005*	-0.001	-0.01**	-0.01**	-0.01**	-0.002	-0.01**	-0.01**	-0.005	-0.001	-0.03**	-0.02**
	{0.003}	{0.002}	{0.002}	{0.004}	{0.003}	{0.002}	{0.002}	{0.004}	{0.005}	{0.005}	{0.005}	{0.007}
Male Operator	-0.132	-0.002	-0.117	-0.46**	-0.139	-0.002	-0.137	-0.321	-0.59**	-0.59**	-0.41**	-1.21**
	{0.112}	{0.095}	{0.095}	{0.210}	{0.114}	{0.095}	{0.099}	{0.206}	{0.208}	{0.176}	{0.185}	{0.376}
Education	0.074**	0.069**	0.073**	0.050**	0.088**	0.077**	0.084**	0.040*	0.130**	0.140**	0.090**	0.152**
	{0.014}	{0.013}	{0.012}	{0.021}	{0.014}	{0.013}	{0.012}	{0.022}	{0.026}	{0.025}	{0.025}	{0.037}
Age of Operator	0.025**	0.010**	0.023**	0.008	0.027**	0.011**	0.025**	0.006	0.036**	0.011	0.018**	0.014
	{0.004}	{0.004}	{0.004}	{0.008}	{0.005}	{0.004}	{0.004}	{0.008}	{0.009}	{0.007}	{0.008}	{0.013}
Farm Size	0.026*	0.020**	0.016	0.014	0.025	0.016*	0.015	0.001	0.089**	0.095**	0.068**	0.050
	{0.015}	{0.009}	{0.012}	{0.025}	{0.015}	{0.009}	{0.011}	{0.026}	{0.026}	{0.019}	{0.020}	{0.042}
Rainy Season	-0.062	-0.034	-0.043	-0.218*	-0.058	-0.017	-0.026	-0.199*	-0.101	-0.086	-0.103	-0.306
	{0.077}	{0.071}	{0.070}	{0.117}	{0.078}	{0.072}	{0.072}	{0.116}	{0.157}	{0.147}	{0.149}	{0.240}
Gravity Irrigation	0.208**	0.367**	0.024	0.084	0.235**	0.440**	0.069	0.211	0.439**	0.237	-0.067	-0.131
	{0.102}	{0.095}	{0.105}	{0.156}	{0.103}	{0.097}	{0.109}	{0.159}	{0.207}	{0.190}	{0.206}	{0.311}
Pump Irrigation	0.480**	0.337**	0.267**	0.277	0.523**	0.407**	0.262**	0.464**	0.766**	0.436	0.076	0.165
	{0.116}	{0.114}	{0.104}	{0.192}	{0.117}	{0.117}	{0.110}	{0.188}	{0.228}	{0.229}	{0.215}	{0.376}
Local Resident	-0.094	-0.173*	0.144	0.244	-0.069	-0.127	0.141	0.335**	-0.49**	-0.047	0.611**	0.204
	{0.110}	{0.093}	{0.099}	{0.154}	{0.114}	{0.095}	{0.100}	{0.154}	{0.207}	{0.199}	{0.214}	{0.300}
Distance to Pobl	0.000	-0.005	-0.006	-0.014	0.006	-0.010	-0.002	-0.02**	0.008	0.009	-0.011	0.004
	{0.010}	{0.009}	{0.009}	{0.012}	{0.010}	{0.010}	{0.009}	{0.012}	{0.019}	{0.020}	{0.021}	{0.025}
Population	0.042	0.052	0.071*	0.156**	0.020	0.034	0.073*	0.127*	0.212**	0.326**	0.147*	0.410**
	{0.034}	{0.033}	{0.037}	{0.067}	{0.035}	{0.034}	{0.038}	{0.071}	{0.081}	{0.074}	{0.077}	{0.140}
Dist to Extension	-0.08**	-0.001	-0.09**	0.020	-0.09**	0.005	-0.08**	0.039	-0.08**	0.018	-0.14**	0.006
	{0.019}	{0.018}	{0.019}	{0.032}	{0.020}	{0.019}	{0.019}	{0.032}	{0.038}	{0.038}	{0.038}	{0.059}
Urbanization	-0.127**	0.048	-0.026	-0.041	-0.103**	0.040	-0.010	-0.067	-0.161**	0.133*	0.20**	-0.101
	{0.042}	{0.034}	{0.038}	{0.067}	{0.043}	{0.034}	{0.039}	{0.067}	{0.082}	{0.074}	{0.085}	{0.123}
Road Conditions	-0.199**	0.005	-0.138**	-0.183**	-0.182**	-0.000	-0.13**	-0.189**	-0.430**	-0.184*	-0.143	-0.452**
	{0.049}	{0.048}	{0.051}	{0.085}	{0.049}	{0.048}	{0.055}	{0.085}	{0.102}	{0.101}	{0.106}	{0.159}
Rho					0.756**	0.580	0.874	-0.990				
					{0.275}	{0.653}	{0.160}	{207.18}				
Observations	1331	1479	1590	981	1306	1430	1548	921	1331	1479	1590	981
Log likelihood	-1456	-1366.9	-1352.2	-1225.7	-1178	-1173	-1081	-692.8	-1220	-1269	-1168	-795.5

Table A2: Multinomial Logit Estimates: Hiring Without Supervision with Endogenous Labor Contracts

	Land Preparation		Planting		Caring		Harvesting	
	Piece-Rate	Time-Rate	Piece-Rate	Time-Rate	Piece-Rate	Time-Rate	Piece-Rate	Time-Rate
Constant	-3.496	-3.240	1.432	-2.430	-0.143	0.027	-0.739	-0.405
	{1.334}	{0.829}	{1.356}	{0.830}	{2.393}	{0.923}	{1.352}	{1.721}
Farm Size	0.067*	0.084**	0.102**	0.083**	-0.286	0.071**	0.034	0.092
	{0.043}	{0.027}	{0.038}	{0.022}	{0.254}	{0.023}	{0.043}	{0.057}
Male Adults	0.023	-0.138**	-0.208**	-0.169**	-0.414**	-0.154**	-0.016	-0.133
	{0.074}	{0.047}	{0.081}	{0.045}	{0.177}	{0.048}	{0.067}	{0.097}
Female Adults	0.226**	0.153**	0.004	-0.005	0.486**	0.243**	0.015	-0.230
	{0.082}	{0.052}	{0.079}	{0.049}	{0.146}	{0.048}	{0.081}	{0.120}
Rainy Season	-0.211	-0.056	-0.309	0.020	0.217	-0.091	-0.458	0.310
	{0.280}	{0.168}	{0.268}	{0.169}	{0.456}	{0.166}	{0.255}	{0.360}
Average Worker Wage	0.003	-0.012**	-0.016	-0.032**	-0.066**	-0.033**	-0.008	-0.003
	{0.006}	{0.005}	{0.010}	{0.007}	{0.025}	{0.007}	{0.010}	{0.012}
Employer Opportunity Wage	-0.007	-0.005	-0.003	-0.003	0.022	-0.033**	-0.023**	-0.007
	{0.008}	{0.005}	{0.008}	{0.005}	{0.017}	{0.006}	{0.008}	{0.010}
Male Employer	-0.563*	-0.615**	-0.635*	-0.614**	-2.240**	-0.526**	-1.209**	-1.596**
	{0.357}	{0.222}	{0.322}	{0.202}	{0.740}	{0.207}	{0.394}	{0.505}
Education of Employer	0.070	0.148**	0.063	0.189**	-0.204	0.128**	0.155**	0.210**
	{0.046}	{0.028}	{0.046}	{0.028}	{0.110}	{0.027}	{0.040}	{0.051}
Age of Employer	0.042**	0.035**	0.001	0.014*	-0.074**	0.027**	0.015	0.000
	{0.016}	{0.009}	{0.013}	{0.009}	{0.036}	{0.009}	{0.014}	{0.019}
Gravity Irrigation Dummy	0.280	0.541**	0.040	0.423**	1.961**	-0.179	-0.095	-0.369
	{0.394}	{0.221}	{0.389}	{0.217}	{0.962}	{0.232}	{0.332}	{0.464}
Pump Irrigation Dummy	0.965**	0.762**	0.996**	0.279	2.267**	-0.145	0.313	-0.234
	{0.398}	{0.246}	{0.386}	{0.285}	{0.982}	{0.241}	{0.398}	{0.594}
Local Resident	-0.923**	-0.307	-0.605*	0.237	0.815	0.704**	0.361	-0.032
	{0.362}	{0.223}	{0.351}	{0.237}	{0.897}	{0.237}	{0.321}	{0.428}
Distance to Poblacion	0.057*	-0.002	-0.050	-0.017	-0.248*	0.011	-0.034	0.040
	{0.034}	{0.020}	{0.059}	{0.024}	{0.166}	{0.023}	{0.029}	{0.036}
Road Conditions Index	-0.072	0.521**	-0.750**	0.363**	2.088**	0.046	0.667**	-0.335
	{0.202}	{0.109}	{0.304}	{0.114}	{0.705}	{0.121}	{0.170}	{0.260}
Barangay Population	0.213*	0.216**	0.348**	0.357**	0.696**	0.082	0.424**	0.546**
	{0.121}	{0.086}	{0.000}	{0.008}	{0.359}	{0.086}	{0.148}	{0.182}
Urbanization Index	0.104	-0.225**	0.657**	-0.046	-0.240	0.380**	-0.159	0.065
	{0.157}	{0.087}	{0.193}	{0.082}	{0.494}	{0.100}	{0.132}	{0.191}
Distance to Extension	0.148**	0.072*	-0.035	-0.050	0.860**	0.137**	0.007	-0.212**
	{0.073}	{0.041}	{0.087}	{0.043}	{0.262}	{0.042}	{0.064}	{0.087}
Observations	1323		1466		1562		972	
Log likelihood	-1555.879		-1507.039		-1186.412		-1163.053	

Figure 1: A Graphical Representation of Supervision

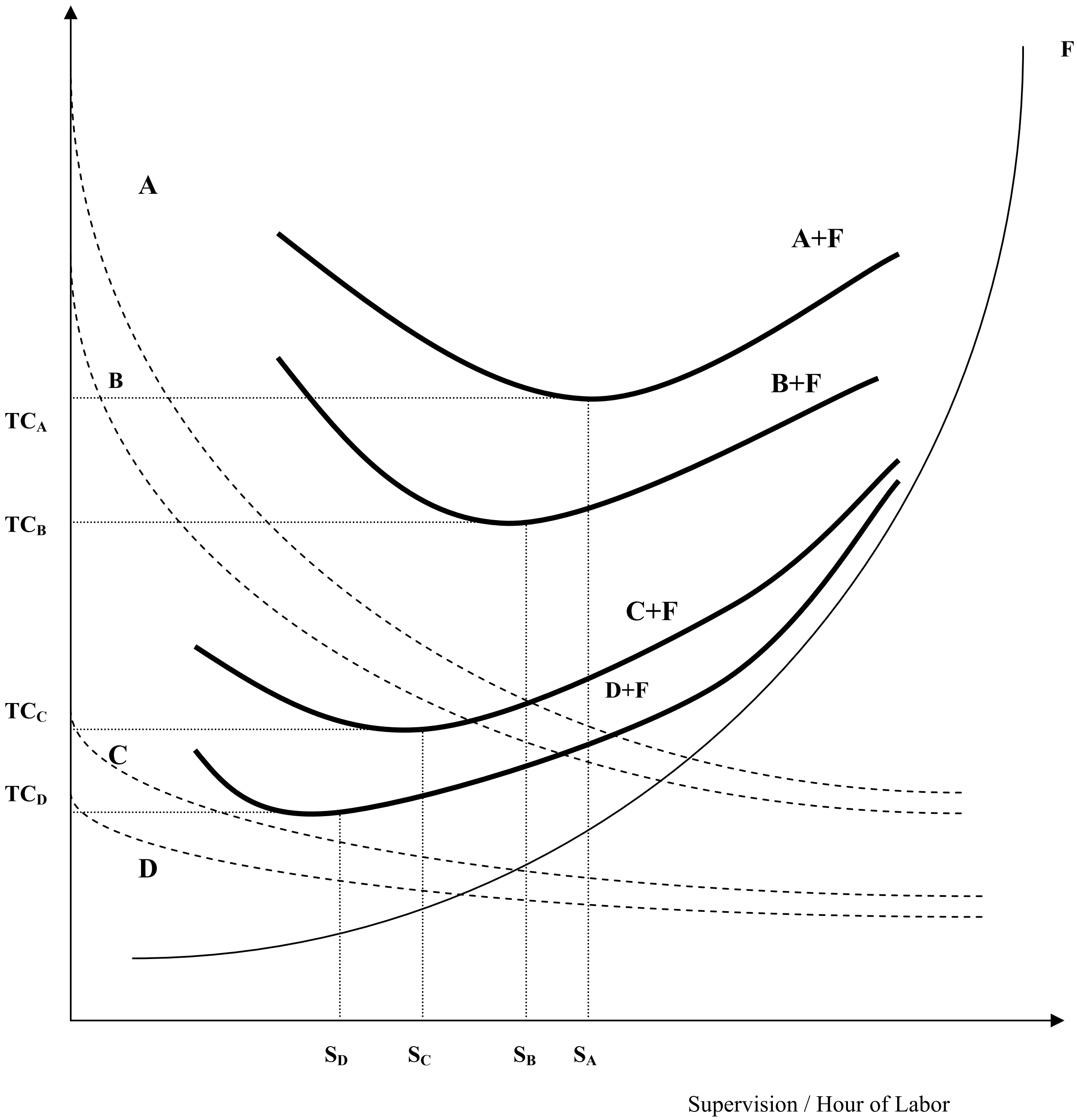
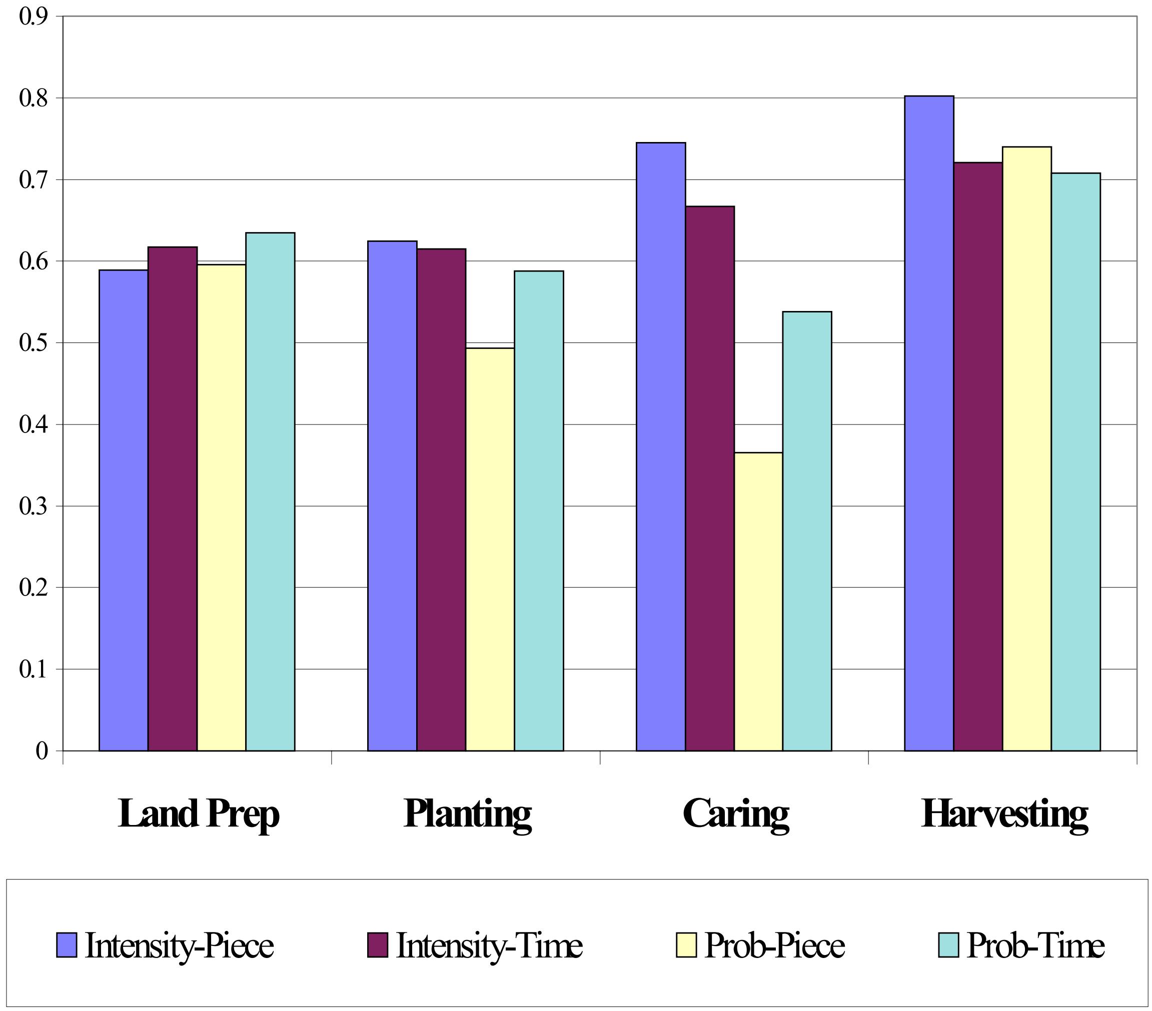


Figure 2: Supervision by Type of Task



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9.02 Yacov Tsur and Amos Zemel - Endangered aquifers: Groundwater management under threats of catastrophic events.

10.02 Uri Shani, Yacov Tsur and Amos Zemel - Optimal Dynamic Irrigation Schemes.

1.03 Yoav Kislev - The Reform in the Prices of Water for Agriculture (Hebrew).

2.03 Yair Mundlak - Economic growth: Lessons from two centuries of American Agriculture.

3.03 Yoav Kislev - Sub-Optimal Allocation of Fresh Water. (Hebrew).

4.03 Dirk J. Bezemer & Zvi Lerman - Rural Livelihoods in Armenia.

5.03 Catherine Benjamin and Ayal Kimhi - Farm Work, Off-Farm Work, and Hired Farm Labor: Estimating a Discrete-Choice Model of French Farm Couples' Labor Decisions.

6.03 Eli Feinerman, Israel Finkelshtain and Iddo Kan - On a Political Solution to the Nimby Conflict.

7.03 Arthur Fishman and Avi Simhon - Can Income Equality Increase Competitiveness?

8.03 Zvika Neeman, Daniele Paserman and Avi Simhon - Corruption and Openness.

9.03 Eric D. Gould, Omer Moav and Avi Simhon - The Mystery of Monogamy.

10.03 Ayal Kimhi - Plot Size and Maize Productivity in Zambia: The Inverse Relationship Re-examined.

11.03 Zvi Lerman and Ivan Stanchin - New Contract Arrangements in Turkmen Agriculture: Impacts on Productivity and Rural Incomes.

12.03 Yoav Kislev and Evgeniya Vaksin - Statistical Atlas of Agriculture in Israel - 2003-Update (Hebrew).

1.04 Sanjaya DeSilva, Robert E. Evenson, Ayal Kimhi - Labor Supervision and Transaction Costs: Evidence from Bicol Rice Farms.