Participation in the Conservation Reserve Program and Off-Farm Work: Implications for Farm and Farm Household Productivity

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Abstract

Using a national survey of U.S farm households, we investigate the interrelationship between participation in the Conservation Reserve Program (CRP) and the decision to work off the farm. We go on examine the effects of these two decisions on farm and farm household efficiency and productivity by estimating stochastic frontier productions for farm output and multiple output-orientated distance functions that consider income from agricultural sales, the CRP and off-farm work as outputs of the farm household. We control for the effects of self selection in estimating both the frontier production and distance functions.

It appears that operators' decisions to work off the farm have led to significant improvements in household resource allocation between farm and other productive activities by farm households -- leading to high technical efficiency for both farm and farm household activities. In contract, participation in the CRP alone leads to the reduction of the technical efficiency and productivity on farm as well as on combined household activities.

Key Words: Conservation Reserve Program, off-farm work, productivity and efficiency.

Introduction

For at least the past half Century, the dependence of farm households in the United States on income from non-farm sources has increased steadily, ultimately narrowing, or actually reversing, the gap between incomes of farm and non-farm households. According to ERS data, income from off-farm work, now the largest component of farm household income, is estimated to be well over twice the net income from farming.

These changes in the composition of farm household income occurred against the backdrop of a traditional commodity-oriented farm policy until environmental goals were elevated along side commodity policy objectives through the conservation compliance provisions of the 1985 farm bill. The Conservation Reserve Program (CRP), introduced at that time, has become the largest Federal program targeting land use, and it now pays farmers about $2 billion per year to remove 34 million acres from crop production.

Currently, CRP payments in the aggregate are small compared with off-farm income, and off-farm work and participation in CRP are quite different livelihood strategies. However, since both decisions lead to substantial reductions in resources under the control of farm households that are committed to agricultural production, they may be related to one another and also have important implications for the efficient allocation of resources between the farm business and farm household.

To understand the relationship between off-farm work by the farm operator and participation in CRP, one objective of this paper is to test if these two decisions are made jointly or are made independently. In the process of conducting this analysis, we find that this decision process is best captured by a bivariate choice model. Based on this estimated model, we develop a better understanding of how these decisions depend on the stock of human capital and risk attitudes of farm operators, as well as land quality, farm size, and participation in other government programs.

A second objective is to investigate the effects of these decisions on the efficiency of resource use by farm households. In contrast to other applications that rely on a simple index as the proxy for technical efficiency, we estimate stochastic frontier production functions for each of the four groups of farms, those that: participate in both CRP and off-farm work; participate only in CRP; participate only in off-farm work; and participate in neither. Since an important contribution of this research is to compare farm productivity and efficiency with that of the household, we also estimate multi-product, output-oriented stochastic distance functions for farm households in each of the four groups.[1] An important methodological contribution that sets our analysis apart from others is that we control for the effects of sample selection in estimating both the frontier production and distance functions. To account for the sample selection effects in decomposing the random and the technical inefficiency components of the errors for the frontier production and distance functions, we extend the two-stage method-of-moments procedure developed by Huang *et al*. (2002) to accommodate two choices. Using the Malmquist formula, the measures of farm and farm household technical efficiency are compared between groups, as are the differences in total factor productivities.

The remainder of the paper begins with the development of the several components of the analytical framework and econometric methods. Next, we describe the data from USDA's 2001 Agricultural Resource Management Survey (ARMS). These data

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[1] Recently, others have also been interested in studying the efficiency of farm households both in the United States and elsewhere (e.g. Paul and Nehring 2005 and Nehring, *et al.* 2005) and abroad (e.g. Chavas, *et al.* 2005).

are used in the empirical analysis because this farm household enumerative survey is USDA's primary vehicle for collecting data on a wide range of issues about agricultural resource use, program participation, and farm and farm household financial conditions and demographics. Next, the empirical results are presented and discussed. The final section summarizes the results and highlights important implications for policy.

Analytical Framework

There are three components to our empirical analysis which has its foundation in a generalization of an endogenous switching regression model (Lee 1978). Within this framework, a bivariate probit model is estimated to capture any interrelationship between CRP participation and the decsion to work off the farm. This also provides the basis for testing a null hypothesis that participation in CRP and off-farm work are separate decisions. As the second component of the analysis, we estimate stochastic production and multiple outputs distance functions for the farm and farm houshold, respectively, and each of them is corrected for self-selection. By then decomposing the error terms for these functions we derive consistent estimates of technical efficiency. Finally, in order to highlight the effects of these two decisions on farm and farm household productivity, we use the Malmquist fromula to compare the productivity and scale efficiencies across groups of farm housholds.

The Discrete Choice Model

As is common in the discrete choice literature, each of these two decisions is assumed to be determined by a comparison between the benefits of participation and non-participation. Consistent with a household production model developed by Chang (2006), the CRP participation decision is determined by comparing the government's potential payment for land in CRP and the reservation per acre return (perhaps risk adjusted) to the farmer of retaining land in production. Similarly, the decision to work off the farm is determined by comparing the potential off-farm market wage with the shadow value (again perhaps risk adjusted) of the farmer's time in farming. The *reduced form* equations that capture these comparisons can be specified as:

(1) $I_1{*} = H_1{'}X_1 + e_1$; $I_2{*} = H_2{'}X_2 + e_2$

$I_i = 1$ *iff* $I_i{*} > 0$; and $I_i = 0$ *iff* $I_i{*} < 0$ i =1, 2,

where X_1 and X_1 are vectors of the exogenous variables, H_1 and H_2 are vectors of the parameters of interest, and e_1 and e_2 are the random disturbance terms. The latent binary choice variables ($I_1{*}$, $I_2{*}$) are the participation decisions of each farmer.[2] The actual binary decision indicator for each decision is observed as 1 (0) only if the latent variable is greater (less) than zero. Suppose the joint distribution of (e_1, e_2) follows a bivariate normal distribution, $N(\begin{bmatrix}0\\0\end{bmatrix},\begin{bmatrix}1 & \rho\\ \rho & 1\end{bmatrix})$, where the correlation coefficient (ρ) captures the joint nature of these two decisions. The bivariate probit model is estimated by maximum likelihood methods with the following log likelihood function:

(3) $$\log L = \sum_{i=1}^{n} \log\Phi\{[(2I_1 - 1)(H_1{'}X_1)],[(2I_2 - 1)(H_2{'}X_2)],[((2I_1 - 1))(2I_2 - 1)\rho]\}$$

Since the correlation coefficient between these two decisions is estimated in the bivariate probit model, a test of the hypothesis that these two decisions are independent is equivalent to a test of the null hypothesis that this correlation coefficient is equal to zero.

Estimating Technical Efficiencies for the Farm and Farm Household

[2] For simplicity, subscript 1 refers to the CRP decision, and subscript 2 refers to the off-farm job of the operator.

To conduct the part of the analysis, we first specify a stochastic farm production frontier, which includes only farm outputs and inputs. We then specify a multi-product, output oriented distance function (e.g. Fare, *et al*. 1994) to account for three farm household outputs (sales from farm production, CRP payments, and off-farm earning). To account for their effects on farm and farm household productivity, we treat the decisions to work off the farm and participate in CRP as endogenous.[3]

Multiple-Output Distance Function

Based on results by Shephard (1970), the multiple-output distance function can be specified as: $D(x, y) = \min\{\theta : (y/x) \in T(x)\}$, where x and y are input and output vectors and T (.) represents the production technology. The output distance function is non-decreasing, positively linearly homogeneous and concave in y but decreasing in x.[4] To estimate this function empirically, linear homogeneity with respect to outputs must be imposed, which can be accomplished by normalizing by one of the outputs (e.g. Coelli and Perelman 2000). The multiple-output distance function can be rewritten as: $D(x, ky) = kD(x, y)$ for any k > 0. The conventional way is to define the factor k as $1/y_j$, where y_j is the output for specific output j. We obtain: $D_0(x, y/y_j) = D_0(x, y^*)$, where y^* are the other output vectors normalized by output y_j.

Assuming the multiple-distance output function can be approximated by a translog functional form, one can obtain:[5]

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[3] Although Paul and Nehring (2005) and Nehring *et al*. (2005) specify the off-farm income as a farm household output, they do not account explicitly for the effects of the decision to work off the farm in estimating technical efficiency.

[4] Throughout the discussion, we focus only on the multiple output distance function, but our results also apply to the single output farm production function which is a special case of this more general form.

[5] The translog functional form is specified since it is flexible, but it still allows us to impose the homogeneity constraints necessary for studying productivity. This specification is commonly utilized in other studies (e.g. Paul and Nehring 2005; Coelli and Perelman 2000)).

(4) $$\ln(D_i / y_{ji}) = \alpha_0 + \sum_{m=1}^{M-1} \alpha_{mi} \ln y^*_{mi} + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln y_{mi} * \ln y_{ni} + \sum_{k=1}^{K} \beta_{ki} \ln x_{ki}$$

$$+ \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kli} \ln x_{ki} * \ln x_{li} + \sum_{k=1}^{K} \sum_{m=1}^{M-1} r_{kmi} \ln x_{ki} * \ln y*_{mi} \quad = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i)$$

where i is the specific participant group (i = 1,…,4), m and n are outputs, l and k are inputs. For convenience, we can rewrite equation (4) as:

(5) $$-\ln(y_{ji}) = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i) - \ln(D_i)$$

Equation (5) is consistent with the standard stochastic production frontier framework (Aigner, Lovell, and Schmidt 1977), since it can be further rewritten as:

(6) $$-\ln(y_{ji}) = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i) + v_i - u_i \; = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i) + \varepsilon_i$$

where the random variable (v_i) is assumed to have a normal distribution, N~(0, σ^2_{vi}). The random variable (u_i) is the technical inefficiency component, and it is assumed to follow a half normal distribution, N^+~ (0, σ^2_{uj}). These two components are assumed to be independent. The random variable (ε_i) is the composite error.

<u>Accounting for Sample Selection in Estimating Stochastic Frontier Functions</u>

Since it is unlikely that the decisions to work off the farm or participate in CRP have no effect on farm output or the level of farm household production, we have a potential self-selection problem, which, if not accounted for, could lead to inconsistent parameter estimates. However, because of the complicated error structure, it is impossible to accommodate the bivariate probit choice mechanism in a one-step MLE procedure to estimate the multiple-output distance function. We resolve this problem through an extension of methods by Huang *et al*. (2002). We first estimate the multiple-distance output function based on the composite error term, and include estimated Inverse Mills Ratios from the bivariate probit choice model to account for sample selection. We then estimate the composite error and decompose it into two error components using the method of moments.

To develop this methodology, we know that the conditional expected production of each group, under the assumption of a trivariate normality of the errors between bivariate probit choice model and equation (6), (e_1, e_2, ε_i), is:

$$(7)\quad -E(\ln(Y_i) \mid I_1, I_2) = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i) + E(\varepsilon_i \mid I_1, I_2) = TL_i(x_i, y_i*, \alpha_i, \beta_i, r_i) + \rho_{1i}\lambda_{1i} + \rho_{2i}\lambda_{2i}$$

where λ_{1i} and λ_{2i} are two inverse mills ratios corresponding to the CRP and off-farm work decisions, respectively.[6] With the correction for the bivariate probit selection problem, it can be shown easily that the OLS estimation of equation (7) for each group yields consistent estimators for ($\alpha_i, \beta_i, r_i, \rho_{1i}, \rho_{2i}$).

To calculate technical efficiency of each participant within each group, the composite error term from equation (6) is decomposed into its random error and technical inefficiency components. In order to do this, we must first recognize that the expected values of the one-sided error terms (E (u_i)) are not equal zero. We must rewrite equation (6) as:

$$(8)\qquad -\ln(\hat{Y}_i) = TL_i(x_i, y_i*, \hat{\alpha}_i, \hat{\beta}_i, \hat{r}_i) + \hat{\varepsilon}_i = Y_i^F - E(u_i) + [v_i - u_i + E(u_i)],$$

which implies that:

$$(9)\qquad TL_i(x_i, y_i*, \hat{\alpha}_i, \hat{\beta}_i, \hat{r}_i) = Y_i^F - E(u_i) \quad \text{and} \qquad \hat{\varepsilon}_i = [v_i - u_i + E(u_i)] = e_{scfi} + E(u_i).$$

Using the predicted residuals ($\hat{\varepsilon}_i$) from equation (7), we can easily see that the parameters (σ_{vi}^2) can be calculated based on the fact that the second and third central

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[6] The formula of λ_{1i} and λ_{2i} can be found in Greene (2002). In contrast to the binary choice mode, they accommodate the correlation between these two choices and differ in each subgroup.

moments of ($\hat{\varepsilon}_i$) should be equal to the second and third central moments of (v_i-u_i) since E(u_i) is constant. The parameters ($\hat{\sigma}^2_{ui}, \hat{\sigma}^2_{vi}$) and the composite error can be calculated as:

$$(10) \quad \hat{\sigma}^2_{ui} = \left(\frac{m_3}{\sqrt{2/\pi}(1-4/\pi)}\right)^{2/3} \; ; \; \hat{\sigma}^2_{vi} = m_2 - (1-\frac{2}{\pi})\hat{\sigma}^2_{u_i} \quad ; \quad \hat{e}_{scf\,i} = \hat{\varepsilon}_i - \sqrt{\frac{2}{\pi}}\hat{\sigma}_{u\,i} .$$

Once this stochastic frontier has been estimated, the calculation of the technical efficiency index requires point estimates for the random variable u_i of each farmer. Following Jondrow, *et al.* (1982), the expected value of u_i given the composite error (v_i-u_i) under the assumption of a half-normal distribution is:

$$(11) \quad E(\hat{u}_{ij} \mid \hat{e}_{scfij}) = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\phi(\frac{\hat{e}_{scfij}\lambda}{\sigma})}{1-\Phi(\frac{\hat{e}_{scfij}\lambda}{\sigma})} - \frac{\hat{e}_{scfij}\lambda}{\sigma}\right] \; ; \qquad j = 1,..,n \text{ and } i = 1,..,4$$

where $\sigma = (\hat{\sigma}^2_{ui} + \hat{\sigma}^2_{vi})^{1/2}$, $\lambda = \frac{\hat{\sigma}_{u_i}}{\hat{\sigma}_{v_i}}$.

Once these conditional expected values are obtained, the technical efficiency index of each farmer within each group can be calculated as:

$$(12) \quad TE_{ij} = e^{-E(\hat{u}\mid\hat{e}_{scf\,ij})} .$$

Estimating Productivity Differences Between Groups

To understand differences in productivity between groups, we utilize the generalized relative TFP index. This index is originally due to Malmquist (1953), but has been generalized to isolate scale efficiencies by Fare, *et al.* (1994).[7]

[7] To use this generalized TFP formula in our comparisons, it is necessary to estimate farm production frontiers and two multiple-distance output functions for each group. One of them is restricted to exhibit constant returns to scale; the other is not. For each function, the error is decomposed using a two-stage method- of-moments as described above.

$$(13)\ \ M(y_g,x_g,y_s,x_s)=\frac{TE^{Vg}(y_g,x_g)}{TE^{Vs}(y_s,x_s)}*\left[\frac{TE^{Vs}(y_s,x_s)}{TE^{Vg}(y_g,x_g)}\frac{TE^{Cg}(y_g,x_g)}{TE^{Cs}(y_s,x_s)}\right].$$

$$*\left[\frac{TE^{Cs}(y_g,x_g)}{TE^{Cg}(y_g,x_g)}*\frac{TE^{Cs}(y_s,x_s)}{TE^{Cg}(y_s,x_s)}\right]^{1/2},$$

where *M*(.) represents the relative TFP index of group *g* relative to group *s* (the reference group). The superscripts V and C refer to the variable returns to scale (VRS) and constant returns to scale (CRS), respectively. The term TE^{Cg} (y_s,x_s) represents technical efficiency for group g using the level of inputs for group *s*.

Total factor productivity is decomposed into three sources. The ratio outside the square brackets measures the relative difference in technical efficiency between group *g* and *s* -- the relative distance between actual production and the frontier function between groups for the VRS technology, or we can say this measures the difference of how the best technologies are used. The first term in brackets measures the ratio of scale efficiencies between groups – the relative difference between the farm households of different groups in terms of the appropriate size of operation compared to the one in which no industry reorganization would improve the efficient production of outputs or use of inputs.[8] The second term in brackets measures the relative difference in technology -- a comparison of the production frontiers between groups.[9]

[8] Improvements could be made if the firm were initially operating on a variable returns to scale production function, but at too small a level (e.g. a point of increasing returns to scale). In this case, efficiency would be improved by having the firm expand its scale while keeping the same input mix. Conversely, if the firm were operating at a level in which returns to scale were decreasing, then efficiency would be improved if the scale of operation were reduced while keeping the same input mix.

[9] To decompose TFP for both the farm and the farm household frontiers, it is necessary to estimate four functions for three of the groups: a CRS and a VRS farm production frontier and a CRS and VRS multi-product distance function. For the group that participates in neither CRP nor off-farm work, we need only estimate CRS and VRS farm production frontiers.

Using equation (13), it is easy calculate the three components of TFP from the estimated frontier functions and to compare these components of TFP across farms and farm households within each group. Such a direct comparison is, however, not possible across groups because the farm and farm household production environments (the frontiers) are assumed to differ by group, and the numbers of farms in each group also differ. Therefore, by necessity, our comparisons of differences in the three components of TFP between the groups are based on the individual group average.

The Data

The primary farm household data used are from the 2001 Agricultural Resource Management Survey (ARMS), an enumerative survey conducted each year by the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA). This data set differs markedly from the earlier farm costs and return survey in providing the basis for assessing changes in the well being of farm households nationwide. To understand the participation decisions in CRP and off-farm work of farm households, we limit our attention to farms classified as crop farm households because of our interest in examining the effect of CRP participation and off-farm work on farm and household productivity. The final sample count is 2,223.

Besides ARMS data set, we also collect external data sources for the information of land quality, local area economic characteristics, and certain aspects of the physical terrain. The economic characteristics of local area are merged into our ARMS data set based on the county-level from the Bureau of Economic Analysis income files in 2000, the Bureau of Economic Analysis employment files in 2000, the Bureau of Labor Statistics, and the Census of Population, STF-3 file. We also define the land quality as the product of a variable reflecting the length of the growing season and the land capability class. The data on the length of the growing season are those used in a global economic model developed to evaluate long-run agricultural and environmental sustainability. Specifically, the growing season variable is an estimate of the length of the rain-fed growing season. The land capability classes are those used in the Natural Resources Conservation Survey (NRCS) and elsewhere to classify land based primarily on physical soil characteristics. This index is calculated based on quantifiable factors in the universal soil loss equation.[10]

Another critical factor affecting CRP participation is the Environmental Benefits Index (EBI). The EBI score in part determines the maximum price that can be paid for land offered into the CRP. It is assigned in each environmental category for each offered parcel as prescribed by the USDA handbook that lists specific details on how points are to be assigned for each conservation practice and land characteristic. It would have been ideal to have an EBI index available for each farm household in the ARMS data, but this was not the case. As an alternative, we use the EBI data from Jaroszewski (2000) to estimate an EBI for major ERS agricultural regions based on the percentage of land in the various conservation practices currently enrolled in CRP. By using these data, it is explicitly assumed that when CRP participation commitments were made, land was likely to be committed to these land uses in similar proportions.

Table 1 contains information summarizing the frequency of CRP participation and off-farm work. According to the marginal frequencies, about 22% of the farm households

[10] The variables are defined as: LQH96 = "high" land quality = GS*(LCC1+LCC2); LQM96 = "medium" land quality = GS*(LCC3+LCC4); and LQL96 = "low land quality = GS*(LCC5+LCC6+LCC7+LCC8), where LCCi = percentage of land in the county that is in soil capability class i, and GS = the ratio of the mean rain-fed season to the mean irrigated season.

participate in CRP, and in about 56% of them, the operator works off the farm.[11] Out of this sample of 2,223 households, only 282 (about 13%) participate in both activities; 211 (about 10%) participate only in CRP, while 960 (about 43%) participate only in the off-farm labor market. Table 2 contains summary data for important variables.

Empirical Results

The empirical results are discussed in three sections. The first summarizes the several tests of the joint decision structure. The second describes those factors that affect the decision to work off the farm or participate in CRP. Recall that the definitions of the variables used in the analysis are in Table 2. The third section describes our analysis of differences in technical efficiency and total factor productivity among the four separate groups of farm households.

The Bivariate Choice Results

The bivariate probit model is a straightforward extension of the binary choice case, but it allows for a correlation between each binary choice. This special characteristic provides the basis to justify the joint rather than an independent decision specification.

Table 3 presents the maximum likelihood estimation of the bivariate probit model. The parameter (ρ), the correlation between the error terms in the two participation equations does capture the joint nature of these two decisions: $\rho = 0.12$, and it is statistically different from zero. More formally, the independence assumption between CRP and off-farm work decisions can be tested through a likelihood ratio test (LR) under the null hypothesis that the parameter (ρ) is equal to zero. The LR test value of our

[11] The participation rate of our study is weighted by full sample weights, since we are interested in the farm household population. Our results are compatible with those by Ahearn and Lee (1991); According to data from the Census of Agriculture, about 30% of farm operators worked some off the farm in 1929, and this increased to about 53% by 1982.

model is 7.1, is greater than the critical value (3.8) for a 95% confidence level; thus we reject the null hypothesis that these two decisions are made independently.

Determinants of CRP Participation

According to the estimated bivariate probit model, participation in CRP depends generally on some characteristics of the farm, the farm operator, land quality, and the circumstances in the local economy (Table 3). The probability of participation in CRP increases with farm size (CROPSIZ1), but the probability of participation is lower if the farm is primarily engaged in vegetable or nursery production (CROP456), rather than cash grain production. This difference probably reflects the higher opportunity cost of vegetable or nursery farms of removing land from production.

In addition to the negative effect of the opportunity cost of land on participation, one could also hypothesize that the likelihood of participation would rise with the level of the annual CRP payments. Unfortunately, it is impossible to include such a variable in participation equations such as this, because of the sample selection problem. Although we have no information on actual bids or bids accepted for our sample farms, but we do find that farm households located in areas where the EBI scores for land enrolled are high are more likely to participate in CRP, *ceteris paribus*. It is likely that in areas where the EBI scores were high, farmers might well expect to have higher bids accepted.

Based on the measures of soil quality in the region described above, participation in CRP rises as the proportion of land in the surrounding county is classified as high (LQH_96) or as low (LQL_96) quality. This result suggests that CRP participation may be higher in areas where land is well suited for agriculture and lower in the areas where it is less suitable for crop production.

There are two variables that suggest participation in CRP has something to do with the life-cycle of the farm operator. The likelihood of CRP participation increases with age (OP_AGE). Thus, as farmers get older, committing some land to CRP may be one way of reducing operator labor requirements on the farm. This may also be a way of holding onto farmland assets until they are needed for the retirement years, or so that they can be passed on through an estate. The fact that there is a positive correlation between the probability of farmers working off the farm and the probability of participation in CRP (as measured by ρ) may also reflect a desire to reduce operator labor requirements as land is taken out of production. Finally, the probability of CRP participation increases as a farmer's education (OP_ED_C) level increases; this is perhaps an indication that investments in human capital might lead to increases in CRP. Our findings square with the notion that investments in human capital may lead to a greater appreciation by farmers in the value of the environmental benefits from CRP.

There are also several ways in which risk can affect the participation in CRP. As aversion to risk increases, the likelihood of participation in a program where payments are certain, such as CRP, should increase. This conclusion is supported by the negative sign on the variable "RISK" in Table 3 (e.g. high values for "RISK" are associated with farmers who prefer more risk). Furthermore, the assumption of decreasing absolute risk aversion (DARA) is also consistent with the fact that decoupled payments, "AMTA_A", reduce the likelihood of CRP participation. With DARA, farmers are likely to be less concerned about diversifying into risk-free income opportunities as wealth increases through decoupled payments.[12] Finally, since commodity-program related loan deficiency payments (LDP_A) reduce farm income variability, these payments also reduce risk averse farmers' concerns for allocating farm resources to CRP.

Participation in other programs also affects the likelihood for CRP participation. For example, if the farmer is enrolled in a voluntary agricultural district, subject to a farmland preservation easement, or is located in an agricultural protection zone or an area zoned exclusively for agricultural use (the variable AGDIST), the farmer is less likely to participate in CRP. Many farmers participate in these types of programs (most of which are state or local programs) out of concern for maintaining their land in agricultural production in rapidly growing areas where there is competition for land for non-agricultural purposes. Therefore, it is hardly surprising that, *ceteris paribus*, these farmers would be less likely to enroll land in a program such as CRP that essentially takes land out of production. The fact that the likelihood of CRP participation falls as the proportion of population that is urban rises would seem to reinforce this explanation.[13] In contrast, farmers who participate in EQIP are also more likely to participate in CRP. Participation in both EQIP and CRP could reflect a farmer's stewardship for the environment (reflected in our theoretical section) by removing venerable land from production, while at the same time using more environmentally friendly practices on land still in production.

Determinants of Off-Farm Work Decision

As expected, the decision of the farm operator to engage in off-farm work also depends on characteristics of the farm, the farm operator, and the circumstances in the

[12] By assuming non-constant absolute risk aversion, Hennessey's (1998) framework is also consistent with our results in the sense that he shows that under these conditions, decoupled payments can affect crop production alternatives.
[13] Duke (2004) also found that the likelihood of participation in CRP is lower in highly urban areas.

local economy (Table 3). As in much of the existing literature (e.g. Sumner 1982; Benjamin and Guyomard 1994; Abdulai and Delgado 1999), our results continue to confirm the fact that older farmers are more likely to work off the farm.[14] However, the effect is nonlinear. Although the operator's education (OP_ED_C) has a positive effect on the probability of participation in off-farm work, the years of experience on the farm (OP_EXP) has a negative effect that increases at an increasing rate. Farm operators raised on farms (RAISE_OP) are also less likely to work off the farm. Since returns to off-farm labor are likely to be less variable than farm returns, the indication that the likelihood of off-farm participation is lower for farm operators willing to accept more risk (a negative coefficient on "RISK" in Table 3, a variable that increases as a farmer accepts more risk) is consistent with the theory of risk averse behavior, but it is not statistically significant.

The likelihood of working off the farm decreases with family size (H_SIZE), but increases if the spouse is primarily a homemaker (SP_HMAK). This latter result may not square with the fact that the operator's likelihood of working off the farm increases with the spouse working off the farm. To disentangle these results, we might well have to specify the characteristics of household size in greater detail and deal with the fact that the decision of the spouse to work off the farm may be endogenous. Attempts are being made to disentangle these effects in subsequent analysis.

The likelihood of participation in off-farm work declines with farm size (CROPSIZ1) and farm tenancy (TENANCY), and it is lower for vegetable or nursery operations (CROP456). The negative effects on the likelihood of participation of both net worth (NETWORT1) and participation in government programs (e.g. AMTA_A) other

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[14] Our result is not consistent with Whittaker and Ahearn (1991); they found that young operators were more likely than older operators to work off the farm.

than CRP may reflect wealth or scale effects on off-farm labor supply (Goodwin and Mishra, 2004). The negative effect of tenancy (as measured by the proportion of acreage owned) on the likelihood for off-farm job participation reflects a greater commitment to agricultural production (*ceteris paribus*) from operators who own their own land. Finally, there is some indication that the strength of the local economy, as measured by the proportion of jobs that are manufacturing (MANUF), increases the likelihood to work off the farm. The relative extent to which the local economy depends on jobs in the trade sector (TRADE) reduces the likelihood of participation in off-farm work.

Farm and Farm Household Technical Efficiency and Productivity

To compare productivities, we first estimate four separate farm production functions, one for CRP participants and one for non-participants. These are frontier functions and have a translog form. To investigate differences between farm productivity and the overall productivity of the farm household productivity, we also specify and estimate translog multiple-output distance function for three of the four groups. For the group that is neither in CRP nor works off the farm, the farm and household production functions are identical.

For the farm production functions, gross cash sales are used as the measure of agricultural production, while there are four inputs, hours worked on the farm, operated cropland, hired labor cost, and capital.[15] The labor hired cost includes regular hired labor and contract labor. Capital use is measured by the fixed value of building and farm equipment excluded for the value of principal operator's dwelling. The output and input

[15] Output is the same as used by Goodwin and Mishra (2004) to study the effect on efficiency from off-farm work. The list of inputs is similar (but not identical) to those specified by Nehring, *et al*. (2005), and we measure them differently. Any aggregate measure of materials inputs was so collinear with capital that it was eliminated—an implicit assumption is that they are in fixed proportion to capital.

variables used to estimate multiple-output distance function are slightly different from the ones we used for farm production function. Along with the farm production output, we specify two other outputs as the non-farm outputs: the wages and salaries from the off-farm work and the annual payment of CRP as the income from environmental program participation. The hours of the operator and spouse working off the farm are also added to the hours worked on the farm; the aggregated input for land is the sum of the operated cropland area and the acres enrolled in CRP. The rest of the input variables are identical to those in the farm production function.

Tables 4 through 7 contain estimates for the translog farm production functions and multiple output distance functions. To emphasize the differences in farm and farm household production, we report the results by group: the group doing both (Table 4), the group of CRP participants (Table 5), the group working off the farm (Table 6), and the group doing neither (Table 7). The translog production functions fit the data quite well; many of the coefficients are statistically significant individually and when taken as a group. For all models, the estimated production elasticities are positive at the sample means. The production elasticities for farms and farm households are quite different as well. The estimated scale economies differ; For example, the returns to scale (RTS) are much lower for household than for farm production for the group working off the farm (0.57 vs 1.29 from Table 6).[16] For the group receiving CRP payments, the economies of scale for household production are somewhat higher (0.84 from Table 5), but the economies of scale for farm production for this group is nearly identical to that of the

[16] This result is consistent with Paul and Nehring (2005), although those authors do not account explicitly for the sample selection effect of off-farm work.

household. (0.85 from Table 5). The same is true for the group of farms that participate in CRP and work off the farm (0.97 vs. 1.01 from Table 4).

Measures of Farm and Farm Household Technical Efficiency and Productivity

We estimate differences in technical efficiency by decomposing the two error components of the stochastic farm production and multi-product distance functions. The Malmquist TFP Index formula provides a method to calculate differences between groups, in terms of technical and scale efficiencies, production frontiers, and total factor productivities. In making the comparisons across groups, the components of TFP are based on the average value of each component for each group; the comparisons are reported as ratios of average efficiency indexes for each group compared to the average efficiency indexes for the group that participates in neither off-farm work nor CRP. (Since this reference group does not participate in off-farm work and CRP, household production and farm production are the same.) These comparisons are reported in Table 8.

We focus initially the technical efficiencies between groups. When comparing only farm production for this group working off the farm and the reference group, the average efficiencies are nearly the same (a ratio of 1.01).[17] However, for total household production; the ratio of average technical efficiencies for these two groups is 1.56. From this evidence, it appears that these the operators' decisions to work off the farm have led to significant improvements in resource allocation resulting in much higher technical efficiencies of household production.

In contrast, the story is quite different for those farms that have land in CRP, but where the operators do not work off the farm. For this group of farms, the average

[17] In contrast, Goodwin and Mishra (2004) found that there was a slight decrease in efficiency due to off-farm work.

technical efficiency for household production is well below that for those in the reference group (a ratio of 0.76). It is difficult to know why the technical efficiency for this group is so low, but one possible explanation is that the efficiency of production is reduced by removing land from production without making comparable reductions in labor used on the farm.

Evidence to add support to this explanation is found by examining the technical efficiency of farm households participating in both programs. It is for this group, compared with the reference group, that we find the ratios of technical efficiencies for both the farm and the household to be greater than unity (1.25 and 1.69, respectively). Since participating in both programs allows these farm households to reallocate both family labor and land to other income earning uses simultaneously, the household seems able to improve resource allocation both at the farm and the household levels.

Relative to the reference group, the ratios of the scale efficiencies for the other three groups are higher for farm household production than they are for farm production. Moreover, the ratios of scale efficiencies for household production are all larger than unity. These results would seem to suggest that by withdrawing some resources from agriculture these three groups of farms come closer to an optimal scale of production, given other fixed resources, etc.

The combined effects of participation in CRP and off-farm work are perhaps best seen in the comparisons of total factor productivity relative to the reference group. From the information in Table 8, we see that participation in CRP, committing to an off-farm job, or both decreases the total factor productivity of the farm operation (ratios for these three groups are 0.93, 0.75, 0.83, respectively). These differences are due to the fact that the farm production frontiers for these three groups are lower than for the reference group. However, the situation is quite different if farm household production is considered. For two of the three groups (those in CRP and working off the farm and those working off the farm), the higher technical and scale efficiencies relative to the reference group outweigh the fact that the production frontiers lie inside that of the reference group—resulting in higher relative levels of total factor productivity; the ratios are 1.15 and 1.51, respectively. In contrast, the average total factor productivity of the farm household for those participating only in CRP is lower than for the reference group (a ratio of 0.87).

Concluding Remarks and Policy Implications

To better understand the interaction between the farm business and the farm household, this paper focuses decisions by the farm household regarding participation in CRP and off-farm work, and the efficiency of resource use by the farm and the household. We begin by identifying those factors that explain participation in these two major non-production related sources of income for farm households. For the appropriate subgroups of farm households, and accounting explicitly for the effects of these two decisions in estimating frontier farm production multiple output distance functions for farm households, we are able to compare differences of the farm and farm household production across subgroups of farms in terms of the technical and scale efficiencies and total factor productivities.

We find substantial evidence to support the hypothesis that decisions by the farm household to participate in CRP and to work off the farm are made jointly rather than independently. Participating in CRP depends generally on some characteristics of the farm (including the type of farm), the farm operator (including age, experience, and attitudes to risk), land quality, and the circumstances in the local economy. There are also some differences in participation by major ERS production region. As one would expect, decisions to work off the farm are related to many of these same factors, although the direction and magnitude of some of the effects are quite different. It is also true that both decisions are affected by participation in other farm programs. In particular, the probability of participation in CRP increases with farm size, but perhaps due to the higher opportunity cost of land removed from production, the probability of participation is lower if the farm is primarily engaged in vegetable or nursery production, rather than cash grain production.

To shed additional light on the effects of these two decisions on farm and farm household resource allocation, we estimate frontier farm and multiple output distance function for each group. Our results suggest that participation in CRP has no detrimental effect for technical efficiency if only farm production is considered. However, if one takes a broader view that includes the entire set of household production activities, both the average technical efficiency and total factor productivity for this group are well below those for the group that participates in neither CRP nor off-farm work. Quite the opposite is true for the group that participates in both CRP and off-farm work and the group that only works off the farm.

From this evidence, it appears that the operators' decisions to work off the farm (including those that also participate in CRP) have led to significant improvements in resource allocation if one views the situation from the perspective of the entire farm household. It is difficult to know why the reverse is true for those participating only in

CRP. One possible explanation is that the efficiency of production is reduced by taking land out of production without making comparable reductions in labor used on the farm.

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Table 1: Sample Proportion of the Joint Choice

	CRP		
OP	No (%)	Yes (%)	Total (%)
No (%)	35	9	44
Yes (%)	43	13	56
Total (%)	78	22	100

*** Weighted with full sample weights*

Table 2: Summary Statistics

Variable	Variable Definitions	Mean	Std. Dev.
Program Participation			
CRP	If the household enroll in CRP or CREP (=1); otherwise (=0)	0.23	0.42
OP	If the operator worked off the farm (=1); otherwise (=0)	0.56	0.50
Characteristics of the Operator and Spouse			
OP_AGE	Age of the operator	54.57	13.71
OP_ED_C	Education level of the operator (years)	13.08	2.45
OP_EXP	Years of the operator working on farm job	25.50	63.00
RISK	Risk preference of the operator; =0 if risk averse, 10 if risk loving	4.43	2.46
RAISE_OP	If the operator was raised on the farm (=1); otherwise (=0)	0.79	0.41
SP_HMAK	If the spouse is a home maker (=1); otherwise (=0)	0.25	0.43
H_SIZE	Number of household members	2.74	1.26
Farm Household Characteristics of the Farm			
CROPSIZ1	Operated acreage of cropland divided by 1,000	0.32	0.68
TENANCY	Owned acreage devided by total acreage	0.95	2.08
CROP456	If vegetable, fruit, or nursery farm, (=1):otherwise (=0)	0.21	0.41
AMTA_A	Per acre AMTA (Agricultural Market Transition Act) payment	5.42	12.57
LDP_A	Per acre LDP (Loan Deficiency Payment) payment	8.25	18.63
NETWORT1	Household networth value ($100,000)	4.61	15.70
AGDIST	If farm in local agricultural preservation program (=1); otherwise (=0)	0.05	0.22
Environmental Characteristics			
EBI	Environmental benefit index	61.67	3.85
LQH_96	Index of high quality land of 1996	0.33	0.25
LQL_96	Index of low quality land of 1996	0.23	0.19
EQIP	If participate in EQIP (=1), otherwise(=0)	0.00	0.05
Locational Factors and Local Economic Conditions			
URBAN	Percent of labor market area's population living in urban areas, (1990 census)	56.06	22.17
MANUF	LMA's employment in manufacturing (%), lagged one year	13.84	6.90
TRADE	LMA's employment in wholesale and retail trade (%), lagged one year	20.32	2.35
REGN1	If located in ERS region 1(Heartland) (=1); otherwise (=0)	0.28	0.45
REGN3	If located in ERS region 3 (Northern Great Plains) (=1); otherwise (=0)	0.08	0.27
REGN567	If ERS region 5 (E.Uplands), 6 (S.Seaboard), 7 (Fruitful Rim) (=1); otherwise (=0)	0.29	0.45
REGN9	If located in ERS region 9 (Mississippi Portal) (=1); otherwise (=0)	0.05	0.22

Table 2: Summary Statistics (cont.)

Variable	Variable Definitions	Mean	Std. Dev.
Production Performance			
OUTPUT	Agricultural sales ($1,000)	60.39	218.92
CRPOUT	CRP Annual Payment ($1,000)	1.42	5.20
OFFOUT	Income of Off-Farm Work ($1,000)	9.28	47.41
HOUR_OFF	Hours worked off the farm by operator and spouse	1,980	1,648
ACRE_CRP	Acres enrolled in CRP	37.77	163.99
HOUR	Hours worked on the farm by the operator and spouse	1,694	1,401
LC_C	Operating cost, including livestock expense,crop expense,energy expense	36,267	98,346
LAND	Operated acres	407	923
CAPITAL	Value of total non-current assets minus the value of the principal operator dwelling	466	1600
LABOR	Hired labor cost	9,823	61,908

* Note: All variables are weighted with full sampling weights

Table 3: Estimated Bivariate Probit Model

Variable	Coefficient	Std. Dev.	t-value
	CRP Equation		
Constant	-4.95	1.41	-3.50
OP_AGE	0.03	0.00	9.41
OP_ED_C	0.07	0.02	4.62
RISK	-0.06	0.02	-3.20
EQIP	1.13	0.41	2.76
LQH_96	0.54	0.21	2.57
LQL_96	-1.07	0.33	-3.28
EBI	0.05	0.02	2.18
AGDIST	-1.16	0.27	-4.38
AMTA_A	-0.03	0.00	-6.33
LDP_A	-0.01	0.00	-5.06
CROP456	-1.92	0.27	-7.24
CROPSIZ1	0.23	0.04	5.73
REGN1	0.16	0.10	1.56
REGN567	-0.39	0.14	-2.68
REGN9	1.25	0.27	4.69
URBAN	-0.01	0.00	-7.91
	OP Equation		
Constant	-0.93	0.58	-1.59
OP_AGE	0.14	0.02	8.40
OP_AGESQ	-1.63	0.15	-11.09
OP_ED_C	0.06	0.01	4.27
OP_EXP	-0.02	0.00	-4.98
OP_EXPSQ	0.00	0.00	4.90
RAISE_OP	-0.45	0.10	-4.65
RISK	-0.02	0.01	-1.19
SP_HMAK	0.25	0.07	3.42
AMTA_A	-0.01	0.00	-3.04
LDP_A	0.00	0.00	-1.91
H_SIZE	-0.09	0.03	-2.93
CROPSIZ1	-0.60	0.03	-18.68
NETWORT1	0.00	0.00	-0.88
TENANCY	-0.04	0.02	-1.89
CROP456	-0.88	0.09	-9.36
REGN3	0.29	0.13	2.17
REGN567	-0.21	0.08	-2.80
MANUF	0.02	0.01	3.61
TRADE	-0.04	0.01	-2.84
RHO	0.12	0.05	2.29
Log-likelihood	-1871.73	LR test*	7.13

** The null hypothesis for LR test is: RHO=0,*
critical value of x^2 (0.95,1) is 3.84

Note: Definitions of the variables are listed in Table 2.

Table 4: Translog Farm and Houshold Production Functions (1,1) Group

	Multiple Output Distance Function			Farm Production Function		
Variable	Coefficient	Std. Dev.	t-value	Coefficient	Std. Dev.	t-value
Constant	8.53	11.10	0.77	-17.42	6.18	-2.82
LGHOUR	0.34	2.07	0.16	1.23	2.13	0.58
LGLAND	1.84	0.86	2.15	-0.12	1.01	-0.12
LGLABOR	-0.56	0.48	-1.16	0.99	0.46	2.13
LGCA	-4.39	1.51	-2.90	2.83	1.70	1.66
HOURSQ	-0.12	0.10	-1.17	-0.11	0.16	-0.66
LANDSQ	-0.01	0.08	-0.09	-0.09	0.10	-0.84
LABORSQ	0.00	0.00	0.68	0.01	0.01	1.05
CASQ	-0.07	0.08	-0.91	0.20	0.13	1.56
HOURLAND	-0.29	0.10	-2.84	0.52	0.21	2.46
HOURLABR	0.06	0.05	1.24	-0.16	0.05	-3.33
HOURCA	0.53	0.18	3.03	-0.28	0.23	-1.19
LANDLABR	-0.01	0.02	-0.29	0.05	0.04	1.49
LANDCA	0.05	0.15	0.34	-0.40	0.13	-3.09
LABORCA	-0.01	0.03	-0.39	-0.04	0.06	-0.63
OUT21SQ	0.04	0.02	2.24	--	--	--
OUT31SQ	-0.09	0.04	-2.47	--	--	--
OUT23	0.04	0.04	0.90	--	--	--
OUT2HOUR	0.09	0.04	2.41	--	--	--
OUT2LAND	0.04	0.07	0.60	--	--	--
OUT2LABR	0.02	0.01	1.46	--	--	--
OUT2CA	-0.08	0.07	-1.17	--	--	--
OUT3HOUR	0.05	0.06	0.89	--	--	--
OUT3LAND	-0.03	0.11	-0.28	--	--	--
OUT3LABR	-0.04	0.02	-1.93	--	--	--
OUT3CA	-0.02	0.08	-0.22	--	--	--
IMR_CRP	0.08	0.12	0.68	0.51	0.23	2.27
IMR_OP	0.13	0.12	1.08	0.51	0.26	1.99
Elasticities**						
Hour	0.22			0.17		
Land	0.43			0.46		
Labor	0.01			0.09		
Capital	0.31			0.30		
RTS	0.97			1.01		
Adjust R^2	0.95			0.63		
Wald Test*	71.91			12.15		
Wald Test$^+$	1.54			7.42		

** the null hypothesis is: all parameters are equal to zero*

$^+$ the null hypothesis is: IMR_CRP=IMR_OP are jointly equal to zero; x^2 (2,0.95)=5.99; x^2 (2,0.90)=4.61

*** Productiom elasticities, calculated on the sample mean.*

Note: Variables defined in Table 2. IMR_CRP and IMR_OP are inverse mills ratios for CRP and OP decisions.

Table 5: Translog Farm and Houshold Production Functions (1,0) Group

	Multiple Output Distance Function			Farm Production Function		
Variable	Coefficient	Std. Dev.	t-value	Coefficient	Std. Dev.	t-value
Constant	11.00	4.24	2.60	-20.00	6.13	-3.26
LGHOUR	-0.85	1.45	-0.59	1.85	1.79	1.03
LGLAND	-1.01	1.12	-0.91	1.61	1.32	1.22
LGLABOR	-0.29	0.21	-1.41	0.49	0.28	1.75
LGCA	-1.09	1.17	-0.93	1.77	1.24	1.42
HOURSQ	0.07	0.15	0.44	-0.13	0.19	-0.69
LANDSQ	0.11	0.09	1.31	-0.28	0.10	-2.81
LABORSQ	-0.02	0.01	-2.94	0.01	0.01	1.41
CASQ	-0.01	0.11	-0.10	-0.08	0.12	-0.67
HOURLAND	-0.20	0.18	-1.11	0.29	0.22	1.29
HOURLABR	0.02	0.04	0.48	-0.05	0.06	-0.89
HOURCA	0.20	0.16	1.25	-0.18	0.19	-0.95
LANDLABR	0.08	0.03	2.61	-0.05	0.04	-1.38
LANDCA	-0.03	0.16	-0.22	0.11	0.16	0.65
LABORCA	-0.05	0.03	-1.66	0.04	0.04	1.06
OUT21SQ	0.04	0.01	3.72	--	--	--
OUT2HOUR	0.12	0.05	2.47	--	--	--
OUT2LAND	0.01	0.07	0.09	--	--	--
OUT2LABR	0.00	0.01	-0.55	--	--	--
OUT2CA	-0.03	0.08	-0.46	--	--	--
IMR_CRP	0.04	0.10	0.41	0.25	0.15	1.68
IMR_OP	0.05	0.11	0.45	0.38	0.17	2.24
Elasticities**						
Hour	0.14			0.31		
Land	0.41			0.02		
Labor	0.13			0.18		
Capital	0.16			0.35		
RTS	0.84			0.85		
Adjust R^2	0.92			0.85		
Wald Test*	109.84			68.75		
Wald Test$^+$	0.29			7.94		

** the null hypothesis is: all parameters are equal to zero.*

$^+$ the null hypothesis is: IMR_CRP=IMR_OP are jointly equal to zero; x^2 (2,0.95)=5.99; x^2 (2,0.90)=4.61

*** Production elasticities, calculated on the sample mean.*

Note: Variables defined in Table 2. IMR_CRP and IMR_OP are inverse mills ratios for CRP and OP decisions.

Table 6: Translog Farm and Houshold Production Functions (0,1) Group

	Multiple Output Distance Function			Farm Production Function		
Variable	Coefficient	Std. Dev.	t-value	Coefficient	Std. Dev.	t-value
Constant	13.86	8.93	1.55	-1.31	0.67	-1.96
LGHOUR	-3.70	1.98	-1.87	0.23	0.20	1.16
LGLAND	1.28	0.70	1.83	-0.39	0.24	-1.61
LGLABOR	0.10	0.28	0.36	-0.01	0.08	-0.07
LGCA	-0.78	0.69	-1.13	-0.07	0.20	-0.37
HOURSQ	0.24	0.11	2.09	0.00	0.02	-0.26
LANDSQ	-0.07	0.02	-4.29	0.11	0.02	5.45
LABORSQ	-0.03	0.01	-3.81	0.05	0.00	10.51
CASQ	-0.01	0.01	-0.67	0.04	0.02	2.34
HOURLAND	-0.14	0.08	-1.69	0.04	0.03	1.29
HOURLABR	0.01	0.03	0.22	-0.03	0.01	-1.78
HOURCA	0.10	0.08	1.16	0.02	0.03	0.80
LANDLABR	0.00	0.01	0.29	-0.03	0.01	-2.93
LANDCA	0.00	0.02	-0.22	-0.06	0.03	-1.97
LABORCA	0.00	0.01	0.47	-0.01	0.01	-0.51
OUT21SQ	--	--	--	--	--	--
OUT31SQ	-0.07	0.01	-7.07	--	--	--
OUT23	--	--	--	--	--	--
OUT2HOUR	--	--	--	--	--	--
OUT2LAND	--	--	--	--	--	--
OUT2LABR	--	--	--	--	--	--
OUT2CA	--	--	--	--	--	--
OUT3HOUR	0.09	0.01	7.74	--	--	--
OUT3LAND	-0.11	0.02	-5.93	--	--	--
OUT3LABR	0.00	0.01	-0.47	--	--	--
OUT3CA	0.01	0.02	0.43	--	--	--
IMR_CRP	-0.30	0.14	-2.10	-0.05	0.19	-0.24
IMR_OP	0.04	0.13	0.32	-0.10	0.19	-0.55
Elasticities**						
Hour	0.08			0.35		
Land	0.32			0.55		
Labor	0.09			0.23		
Capital	0.08			0.16		
RTS	0.57			1.29		
Adjust R^2	0.84			0.69		
Wald Test*	119.84			72.35		
Wald Test$^+$	5.90			0.58		

** the null hypothesis is: all parameters are equal to zero.*

$^+$ *the null hypothesis is: IMR_CRP=IMR_OP are jointly equal to zero;* x^2 *(2,0.95)=5.99;* x^2 *(2,0.90)=4.61*

*** Production elasticities, calculated on the sample mean*

Note: Variables defined in Table 2. IMR_CRP and IMR_OP are inverse mills ratios for CRP and OP decisions.

Table 7: Production Function (0,0) Group

	Farm Production Function		
Variable	Coefficient	Std. Dev.	t-value
Constant	-4.30	1.97	-2.18
LGHOUR	-0.86	0.33	-2.62
LGLAND	0.48	0.33	1.42
LGLABOR	0.62	0.09	6.57
LGCA	0.57	0.51	1.12
HOURSQ	0.14	0.02	5.66
LANDSQ	0.05	0.01	4.80
LABORSQ	0.04	0.00	14.48
CASQ	0.09	0.03	2.83
HOURLAND	-0.01	0.05	-0.24
HOURLABR	-0.03	0.01	-2.29
HOURCA	-0.07	0.07	-1.00
LANDLABR	-0.04	0.01	-5.20
LANDCA	-0.05	0.03	-2.11
LABORCA	-0.07	0.01	-6.15
IMR_CRP	0.15	0.12	1.18
IMR_OP	-0.46	0.08	-5.59
Elasticity**			
Hour	0.46		
Land	0.31		
Labor	0.38		
Capital	0.31		
RTS	1.46		
Adjust R^2	0.82		
Wald Test*	330.69		
Wald Test$^+$	43.12		

** the null hypothesis is: all parameters are equal to zero*

$^+$ the null hypothesis is: IMR_CRP=IMR_OP are jointly equal to zero;
x^2 (2,0.95)=5.99; x^2 (2,0.90)=4.6

*** Production elasticities, calculated on the sample mean*

Note: Variables defined in Table 2. IMR_CRP and IMR_OP are inverse mills ratios for CRP and OP decisions.

Table 8: Technical and Scale Efficiencies and Productivities

Groups	Farm	Household
	Technical Efficiency	
T.E (CRP=OP=1)	0.54	0.72
T.E (CRP=1)	0.42	0.32
T.E (OP=1)	0.43	0.67
T.E (None)	0.43	--
	*Ratios of Technical Efficiencies**	
T.E Ratio (CRP=OP=1 vs none)	1.25	1.69
T.E Ratio (CRP=1 vs none)	0.98	0.76
T.E Ratio (OP=1 vs none)	1.01	1.56
	*Ratios of Scale Efficiencies**	
T.E Ratio (CRP=OP=1 vs none)	0.99	1.11
T.E Ratio (CRP=1 vs none)	1.13	1.24
T.E Ratio (OP=1 vs none)	0.87	1.29
	*Ratios of Production Frontiers**	
P.F Ratio (CRP=OP=1 vs none)	0.67	0.61
P.F Ratio (CRP=1 vs none)	0.84	0.93
P.F Ratio (OP=1 vs none)	0.86	0.75
	*Ratios of Total Factor Productivities**	
T.F.P Ratio (CRP=OP=1 vs none)	0.83	1.15
T.F.P Ratio (CRP=1 vs none)	0.93	0.87
T.F.P Ratio (OP=1 vs none)	0.75	1.51

**All ratios are calculated based on the non-participant group.*

** For the non-participant group, there is no household production.*

** Each efficiency index is based on the sample mean of each group.*