Does Participation in the Conservation Reserve Program and Off-Farm Work Affect the Level and Distribution of Farm Household Incomes?

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Abstract

Using a national survey of U.S farm households, this paper investigates the interrelationship among the decisions to work off the farm by the operator and the spouse, and participation in the Conservation Reserve Program (CRP). The effects of these three decisions on farm household income are also examined. By estimating a heteroscedastic household income function, we identify the effects of participating in these activities on the average level of farm household income and its variation within each sub-group of farms involved in the several combinations of activities.

Our empirical results support the hypothesis that participation in the CRP and decisions to work off the farm by the operator and the spouse are made jointly rather than independently. The operators' decisions to work off the farm and to participate in CRP increase the mean level of the household income, while the spouses' decisions to work off the farm help decrease the variation in household income among households in that sub-group.

Key Words: Conservation Reserve Program, off-farm work, farm household income.

Background

For years, improvements in the well being of farm households have been possible through the interaction between technological adoption that released labor from farms and economic growth that pulled labor off farms. The dependence of farm households on income from non-farm sources has increased steadily, narrowing, or actually reversing, the gap between incomes of farm and non-farm households. According to ERS data, off-farm income is now the largest component of farm household income, about $120 billion at the start of the new millennium; net income from farming is only about $50 billion.

Until the mid-1980s, changes in the composition of farm household income occurred against the backdrop of a commodity-oriented farm policy. Through the conservation compliance provisions of the 1985 farm bill, environmental goals were elevated along side commodity policy objectives. Spending on an expanded number of provisions offering incentives to participate in environmentally related programs will rise by 80% under the new farm legislation—to a 10-year total of $38.6 billion. The Conservation Reserve Program (CRP), the largest Federal program targeting land use, pays farmers $2 billion a year to remove 34 million acres from production.

Although CRP payments are small compared with off-farm income, both may be attractive to farm households for similar reasons. Each can be a significant source of reliable income to farm households not directly related to the agricultural production, a characteristic that may gain significance as commodity-related farm support is reduced and farmers' are exposed to greater market price risk. Moreover, CRP and off-farm work remove substantial resources from agricultural production. It is reasonable to hypothesize that the decisions are interrelated.

With this as a working hypothesis, one primary purpose of this paper is to determine if the decisions of farm operators and their spouses to work off the farm are made jointly and in conjunction with participating in the CRP. We extend the analysis to determine how these decisions interact with socio-economic characteristics of the farm and farm household to affect the well-being of farm households, as measured by farm household income, and its variability among farm households with common characteristics. Our empirical analysis is based on 2001 data from the USDA's Agricultural Resource Management Survey (ARMS). This is the annual national survey of farm households.

There has been considerable research on decisions to work off the farm[1] and to participate in programs such as the CRP,[2] but our study is unique in several respects. Although both these decisions to work off the farm and the decision to participate in CRP remove substantial resources from agricultural production, there has been no attempt to investigate the extent to which they are determined jointly or independently. It is important to test for jointness when more than two choices are considered, but there is a high cost in terms of model estimation due to the high dimension computations associated with multivariate distributions.

Using the results from the choice modeling, we are able to control for the endogeneity of these decisions in estimating a farm-household income function.[3] Furthermore, we extend previous analyses by estimating a heteroscedastic income function to identify any systematic effects of decisions to participate in CRP and to work off the farm on farm household income and its variability across households with similar characteristics. Such a heteroscedastic specification has been used by Low and Ormniston (1991) to examine the effects of schooling on the mean and variance in earnings, and by Mullahy and Sindelar (1995) to examine the effects of poor

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[1] The literature considering off-farm work by the farm operator as a single binary choice is extensive, and it is summarized effectively in Hallberg, *et al*. (1991). Recently, there has been a growing body of research documenting the likelihood that the decisions of the operator and the spouse to work off the farm are determined jointly (Huffman and Lange (1989); Gould and Saupe (1989); Kimhi (1994); Lim-Applegate, *et al*. (2002); Kwon, *et al*. (2002)).

[2] For example, Duke (2004) found evidence of the joint nature of decisions by farm households to participate in Delaware's farmland retention programs and federal environmental programs, including CRP and EQIP.

[3] Huffman (1991) underscores the need for this specification of a farm household income function.

health and alcoholism on family income variability. Ours is also the first study to control for potential endogenous participation decisions in such a heteroscedastic specification through a modified treatment effects model in which the predicted probabilities of participation are used as instrumental variables for the three binary choice indicators.

We proceed by outlining a household production model that helps to establish the linkage between the choice modeling and the specification of the income function. A discussion of the econometric choice model is by the specification of the heteroscedastic income function as an endogenous treatment effects model. After then describing the data used and discussing the results, we conclude with a brief summary and a discussion of important policy conclusions.

Conceptual Framework

To focus on the essence of these three combined choices, we assume that all decisions are made by the operator and the spouse of the farm household, denoted by an *m* and *s*, respectively. There are fixed endowments of farmland ($\overline{A}$) and of time for both the operator ($\overline{E}_m$) and the spouse ($\overline{E}_s$). For each of them, time is allocated to leisure (l_m, l_s), farm production (L_m^F, L_s^F), and off-farm work (L_m^{OF}, L_s^{OF}). Land is allocated between crop production (*A*), and CRP (A_e). The household receives income from several sources: agricultural product sales, off-farm work at respective off-farm wage (w_m, w_s) for both the operator and spouse, CRP payment per acre payments (P_e), and decoupled farm payments, (*M*). Finally, we assume that utility depends not only on farm household consumption (*x*) and leisure, but also the improvement in environmental quality (*e*) generated by land committed to CRP. Agricultural production, *y*, depends on land and labor, where $y = f(L_m^F + L_s^F, A)$ is a well-behaved concave production function. To reflect the risky environment in agricultural production, we assume that the commodity price, P, is random; $P = \overline{P} + \eta$, where $\overline{P}$ is the expected price and the random error follows an arbitrary distribution with mean zero and variance σ_η^2, ($\eta \sim (0, \sigma_\eta^2)$).

Given this specification of farm production technology, the agricultural household maximizes expected utility, subject to a full income constraint, a time constraint, and an acreage constraint. The maximization problem can be written as:

(1) $\underset{x, l_m, l_s, A_e}{Max} = E\{U[x, l_m, l_s, e(A_e)]\}$

s.t.

(2) $x = (\overline{P} + \eta) f(L_m^F + L_s^F, A) + w_m L_m^{OF} + w_s L_s^{OF} + P_e A_e + M$

(3) $\overline{E}_m = L_m^F + L_m^{OF} + l_m$

(4) $\overline{E}_s = L_s^F + L_s^{OF} + l_s$

(5) $\overline{A} = A_e + A$.

We can eliminate l_m, l_s, and x by substituting equations (2 through 5) into equation (1). The choice variables are land in CRP (A_e), labor in off-farm work by the operator and spouse (L_m^{OF}, L_s^{OF}), and labor used for agricultural production (L_m^F, L_s^F). The maximization problem is:

(6)

$$\underset{A_e, L_m^F, L_m^{OF}, L_s^F, L_s^{OFs}}{Max} = EU\{[(\overline{P} + \eta)(f(L_m^F + L_s^F, \overline{A} - A_e) + g(L_m^F + L_s^F, \overline{A} - A_e)\varepsilon) + w_m L_m^{OF} + w_s L_s^{OF} + p_e A_e + M], [\overline{E}_m - L_m^F - L_m^{OF}], [\overline{E}_s - L_s^F - L_s^{OF}], e(A_e)]\}.$$

Assuming an interior solution for all endogenous variables, except for (A_e, L_m^{OF}, L_s^{OF}), the first-order necessary conditions for maximization are: [4]

[4] To make the analysis tractable, we follow Fabella (1989) and assume that the marginal utilities of leisure and CRP land are independent. That is: $U_{AeL} = U_{LAe} = 0$.

(7) $$\frac{\partial EU(.)}{\partial A_e} = E\{U_x[-(\overline{P}+\eta) f_A + p_e] + U_e e_{A_e}\} \le 0; \qquad A_e \ge 0\ ; \qquad A_e \frac{\partial EU}{\partial A_e} = 0$$

(8) $$\frac{\partial EU(.)}{\partial L_m^{OF}} = E\{U_x w_m - U_{lm}\} = w_m E(U_x) - E(U_{lm}) \le 0; \quad L_m^{OF} \ge 0; \quad L_m^{OF} \frac{\partial EU}{\partial L_m^{OF}} = 0$$

(9) $$\frac{\partial EU(.)}{\partial L_s^{OF}} = E\{U_x w_s - U_{ls}\} = w_s E(U_x) - E(U_{ls}) \le 0; \quad L_s^{OF} \ge 0; \quad L_s^{OF} \frac{\partial EU}{\partial L_s^{OF}} = 0$$

(10) $$\frac{\partial EU}{\partial L_m^F} = E\{U_x[(\overline{P}+\eta) f_{L_m^F}] - U_{l_m}\} = 0.$$

(11) $$\frac{\partial EU}{\partial L_s^F} = E\{U_x[(\overline{P}+\eta) f_{L_s^F}] - U_{l_s}\} = 0.$$

where U_i is the first-order derivative of the utility function with respect to argument *i*. The optimal levels of (A_e, L_m^{OF}, L_s^{OF}, L_m^F, L_s^F) for the agricultural household are given by the simultaneous solution of equations (7) through (11).

To interpret the economic intuition of the first order conditions, we first focus on the off-farm labor decisions. Equations (8) and (9) provide the optimal conditions for off-farm hours worked by the operator and spouse, respectively. If the hours worked off the farm of the operator/spouse are positive, labor is allocated to off-farm work up to the point where the ratio of the expected marginal utility of leisure to the expected marginal utility of consumption is equal to the respective off-farm wage (w_m / w_s). If a corner solution obtains for either the operator or spouse, the ratio of the expected marginal utility of leisure to the expected marginal utility of consumption may be greater than the off-farm wage.

To interpret the first-order conditions, we must take the expectations of equations (7), (10), and (11). Similar to Isik (2002), we approximate the utility function with a second-order Taylor series expansion, which does not impose constant absolute risk aversion (CARA). By taking expectations and applying the appropriate approximation (Bohrnstedt and Goldberger

(1969)), then substituting these expressions for expected values and covariances into equations (7), (10), and (11), the first-order necessary conditions of these three equations are now:[5]

(7') $$\frac{1}{U_{\bar{x}}}\frac{\partial EU(.)}{\partial A_e} = p_e - \bar{p}f_A + \phi\sigma_\eta^2 ff_A + \frac{U_e e_{Ae}}{U_{\bar{x}}} \leq 0 \ ; \qquad A_e \geq 0 \ ; \qquad A_e \frac{\partial EU}{\partial A_e} = 0$$

(10') $$\frac{1}{U_{\bar{x}}}\frac{\partial EU(.)}{\partial L_m^F} = \bar{p}f_{L_m^F} - \phi\sigma_\eta^2 ff_{L_m^F} - \frac{U_{l_m}}{U_{\bar{x}}} = 0;$$

(11') $$\frac{1}{U_{\bar{x}}}\frac{\partial EU(.)}{\partial L_s^F} = \bar{p}f_{L_s^F} - \phi\sigma_\eta^2 ff_{L_s^F} - \frac{U_{l_s}}{U_{\bar{x}}} = 0.$$

The parameter (ϕ) is the Arrow-Pratt's measure of absolute risk aversion.[6]

The economic intuition behind equation (7') is straightforward. The optimal CRP acreage is determined when the CRP payment (p_e) plus the marginal utility of the environmental benefit of CRP ($\frac{U_e e_{Ae}}{U_{\bar{x}}}$) equals the mean opportunity cost of land in agricultural production adjusted for the risk premium ($\bar{p}f_A - \phi\sigma_\eta^2 ff_A$). From equation (10'), the operator allocates labor to agricultural production up to the point where the marginal utility of leisure ($\frac{U_{l_m}}{U_{\bar{x}}}$) is equal to the mean marginal value product of land in agricultural production adjusted for the risk premium ($\bar{p}f_{L_m^F} - \phi\sigma_\eta^2 ff_{L_m^F}$). Equation (11') is a similar expression for the spouse.

After solving equations (7'), (8), (9), (10'), and (11') simultaneously for the reduced form expressions for the endogenous variables ($A_e, L_m^F, L_m^{OF}, L_s^F, L_s^{OF}$), and substituting them into equation (2), the income function can be shown as a function of all of the exogenous variables:

[5] The derivations of equations (7'), (10'), and (11') are in Chang (2006). To focus on CRP participation, we assume the both the operator and the spouse allocate some time to the farm business.
[6] For simplicity, we assume risk attitudes of the operator and the spouse are the same.

(12) $x = x(w_m, w_s, p_e, \phi, \sigma_\eta^2, M, Z)$.

To make a transition of equation (12) to the empirical analysis, several issues need to be addressed. Since equation (12) can also be viewed as a *reduced* form, representing household income (x) in terms of the off-farm wages (w_m, w_s), per-acre CRP payment (p_e) and other exogenous variables, off-farm wages (w_m, w_s) and per-acre CRP payment (p_e) are only observed for those who have chosen to work off the farm or participate in CRP. Household income, on the other hand, is observable for all observations in our data.

In order to retain all sample observations in the data set in the empirical estimation of an income function, we adopt an approach similar to one discussed by Goodwin and Holt (2002) in which the (potentially unobservable) wages (and CRP payments in our case) are replaced in equation (12) by what their determinants would be in wage and payment functions. This would yield inequalities corresponding to an empirical representation of the participation conditions implied by the first-order Kuhn-Tucker conditions, equations (7) through (9) above. In so doing, we reflect the fact that for those operators or spouses who choose not to work off the farm, their reservation wage (or benefit) for not working off the farm is higher than the market wage. This is consistent with the corner solutions to equations (8) and (9). A similar argument applies to being able to reflect the fact that for those not participating in CRP (a corner solution to equation (7)), the opportunity cost of land in production is higher than the potential CRP payment.

Given an estimated discrete choice structure, it is also necessary to determine the best way to reflect these endogenous choices in the empirical specification of the farm household income function (equation (12)). Since we would lose important information by trying to estimate separate income functions for sub-groups of participants in various combinations of choices, it is not appropriate to adopt the standard sample selection model by Heckman (1979).

In contrast to the sample selection model focusing on sub-samples, we are able to focus on the entire sample by developing a model embodying three endogenous treatment effects, one corresponding to each of the binary choices. Under the endogenous treatment effect model framework, the unobservable off-farm wage for the operator or the spouse or the per-acre CRP payment is replaced by the binary choice index for each choice, which is consistent with the first order Kuhn-Tucker conditions from the theory above. Vella and Verbeek (1999) suggest accommodating these endogenous treatment effects by adding the appropriate Inverse Mills Ratios to the household income function, along with the binary indicators of choices. This strategy provides efficient estimates of the parameters, but when dealing with a three-choice model, it is difficult to derive empirical expressions for these generalized Inverse Mills Ratios. Therefore, as an alternative, we reflect these endogenous choices in the empirical model below by using the estimated predicted probabilities of each choice as instrumental variables for these three binary choice indexes. The details of this specification are discussed in the next section.

Econometric Framework

In this section, we first specify an econometric framework to model the combined decision process. We then specify an income function that accounts for the fact that income is determined along with the endogenous choices from the choice model.

Joint Decisions Process

Following the random utility framework by McFadden (1981), we specify each participation decision as a binary probit choice, but we allow for the correlation between each pair of choices (Figure 1). Each decision is assumed to be determined by the comparison of the net benefit between participation and non-participation in each activity. More precisely, the CRP participation decision is determined by the reservation per acre return (perhaps risk adjusted) to the farm household of retaining the land in production with the government's potential payment for land in the conservation reserve program (CRP). The off-farm job decisions of the farm operator and the spouse are determined by comparing the potential off-farm market wage for each with the respective shadow values of time (again perhaps risk adjusted) in farming. The specifications for these three equations are:

(13) $P^r = A_r X_r + e_r$ and $P^g = A_g X_g + e_g$

(14a) $W_{op}{}^r = B_{rop} S_{r\,op} + u_{rop}$ and $W_{op}{}^g = B_{gop} S_{gop} + u_{gop}$

(14b) $W_{sp}{}^r = B_{r\,sp} S_{rsp} + u_{rsp}$ and $W_{sp}{}^g = B_{gsp} S_{gsp} + u_{gsp}$

where P^r and P^g represent the reservation per acre return, and the potential government per acre payment of CRP; ($W_{op}{}^r$, $W_{op}{}^g$) represent the shadow values for farm labor, and the off-farm wage for the operator; and ($W_{sp}{}^r$, $W_{sp}{}^g$) represent the shadow values of the farm labor, and the off-farm wage for the spouse. The vectors X_r, X_g, S_{rop}, $S_{gop,}$ S_{rsp}, and S_{gsp} are the exogenous variables, and e_r, e_g , u_{rop}, u_{gop}, u_{rsp}, and u_{gsp}, are the random disturbance terms.

The latent binary choice variables (I_1*, I_2*, I_3*) for the decisions are:

(15) $I_1{*} = P^g - P^r = A_g{}' X_g - A_r{}' X_r + (e_g - e_r) = H_1{}' X_1 + e_1$

$$I_2{*} = W_{op}{}^g - W_{op}{}^r = B_{gop}{}' S_{gop} - B_{rop}{}' S_{rop} + (u_{g\,op} - u_{rop}) = H_2{}' X_2 + e_2$$

$$I_3{*} = W_{sp}{}^g - W_{sp}{}^r = B_{gsp}{}' S_{gsp} - B_{rsp}{}' S_{rsp} + (u_{gsp} - u_{rsp}) = H_3{}' X_3 + e_3 ,$$

where the subscript 1 refers to the CRP decision; subscripts 2 and 3 refer to the off-farm job for the operator and spouse, respectively. If the joint distribution of (e_1, $e_{2,}$ e_3) is trivariate normal, the joint distribution of these three error structures can be specified as:

$N(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix})$, where the correlation coefficient between any two choices (ρ_{ij})

captures the joint nature of any pair of decisions.

Since only the actual binary indicator of each decision, I_i, is observed, the observation rules for the latent decision variables are: $I_i = 1$ (the farmer participates in activity i) iff $I_i^* > 0$; and $I_i = 0$ (the farmer does not participate in activity i) iff $I_i^* < 0$ (for $i = 1, 2$, and 3). Given this choice structure, eight potential outcomes (or regimes) can be realized in the data. Based on the observed outcome of each regime, we can define the probability for participating in each regime as a trivariate cumulative normal distribution. For example, the probability of the regime for those households who participate in all three activities can be shown as:

(16)
$$\begin{aligned} P_{11} &= \Pr(I_1 = 1, I_2 = 1, I_3 = 1) = \Pr(e_1 > -H_1' X_1, e_2 > -H_2' X_2, e_3 > -H_3' X_3) \\ &= \int_{-H_1'X_1}^{\infty} \int_{-H_2'X_2}^{\infty} \int_{-H_3'X_3}^{\infty} \phi(I_1, I_2, I_3, \rho_{12}, \rho_{13}, \rho_{23}) dI_1 dI_2 dI_3 \\ &= \Phi(H_1' X_1, H_2' X_2, H_3' X_3, \rho_{12}, \rho_{13}, \rho_{23}) \end{aligned}$$

where $\Phi(.)$ is the cumulative distribution of the trivariate normal distribution. By defining constants, k_1, k_2 and k_3 as $(2I_1\text{-}1)$, $(2I_2\text{-}1)$, and $(2I_3\text{-}1)$, respectively, we can indicate the regime in which the farm household participates. The generalization of the probability of each regime is: $\Phi[k_1 H_1' X_1, k_2 H_2' X_2, k_3 H_3' X_3, k_1 k_2 \rho_{12}, k_1 k_3 \rho_{13}, k_2 k_3 \rho_{23}]$ .Combining the probability of these eight regimes, the maximum likelihood estimator of the three-choice model is based on the log likelihood function:

(17)
$$\log L = \sum_{i=1}^{n} \log\Phi[k_1 H_1' X_1, k_2 H_2' X_2, k_3 H_3' X_3, k_1 k_2 \rho_{12}, k_1 k_3 \rho_{13}, k_2 k_3 \rho_{23}].$$

To estimate equation (17), we use the approach based on the Geweke-Hajivassiliou-Keane (GHK) simulator. It is unbiased for any given number of replications; it generates substantially smaller variances than other simulators; and it has been shown to be the most unambiguously reliable method for simulating normal probabilities (Hajivassiliou, *et al*. 1996).[7] By simulating the multivariate normal probability in the likelihood, it provides a practical alternative to numerical evaluation of the probability integrals.

Identifying the Effects of these Three Combined Decisions on Farm Household Income

To be consistent with the household production model, it is reasonable in specifying an income equation to account for the endogeneity of each binary choice with farm household income. Furthermore, the theory also suggests that participation in CRP and in off farm work would affect the differences in incomes across households with similar characteristics.

By specifying a traditional treatment effects model regarding each decision as a special treatment, the binary choice variable (a zero-one variable) for each decision should be included as an explanatory variable of the income equation:

(18) $Y_t = \beta' X_t + d_1 * I_1 + d_2 * I_2 + d_3 * I_3 + e_t$,

where Y_t is the farm household income and X_t is a vector of factors affecting mean income, I_i (i = 1,…,3) are the binary choice (zero-one) variables for the three decisions, and e_t is an error term.

Because these choices and farm household income are endogenous, in part due to unobserved factors affecting both income and the participation decisions, ordinary least squares (OLS) would produce inconsistent estimators of the parameters in equation (18). We deal with this issue by following the logic outlined above at the end of the discussion of the theoretical model. That is, we control for the endogenous participation decisions (and use them as appropriate indicators of off-farm wages and CRP payments in the empirical counterpart to equation (12)) through a modified treatment effect model. We incorporate the estimated probabilities of participation as instruments for three binary choice indicators into equation (18).

[7] See Train (2003) for a comprehensive review of all available simulators used in empirical analysis.

By using these instrumental variables to estimate this model, the farm household income equation for the entire sample can be specified as:

(19) $Y_t = \beta' X_t + d_1 * \Phi(\hat{H}_1' X_1) + d_2 * \Phi(\hat{H}_2' X_2) + d_3 * \Phi(\hat{H}_3' X_3) + e_t$,

From the trivariate probit choice model estimated above, the marginal probabilities (for participation in CRP, and for off-farm work by the operator and the spouse) are $\Phi(\hat{H}_1' X_1)$, $\Phi(\hat{H}_2' X_2)$ and $\Phi(\hat{H}_3' X_3)$, respectively. Since each predicted probability is correlated with the binary choice variable, but not with farm household income and each is a continuous variable, the (OLS) estimator of equation (19) produces consistent estimates for (β, d_1, d_2, d_3).

To account for systematic effects of these decisions on the variance of farm household income among farms with similar characteristics, we specify a heteroskedastic income function:

(20) $Y_t = \beta' X_t + d_1 \Phi_1(\hat{H}_1' X_1) + d_2 \Phi_2(\hat{H}_2' X_2) + d_3 \Phi_3(\hat{H}_3' X_3) + u_t$

$u_t = g^{1/2}[\alpha' K_t + r_1 \Phi_1(\hat{H}_1' X_1) + r_2 \Phi_2(\hat{H}_2' X_2) + r_3 \Phi_3(\hat{H}_3' X_3)]\varepsilon_t$

where u is the disturbance term with a zero mean and variance, Var (u_t) = σ_u^2 = g(.), under the assumption that E (ε_t) = 0 and Var (ε_t) = 1. The function $g^{½}$(.) determines the variance in income, where K_t is the vector of explanatory variables. Other variables are as in equation (19).

We estimate equation (20) using maximum likelihood methods. Since appropriate initial values of the parameters are crucial for the MLE method, we do use parameter estimates of equation (20) derived using the three-step method originally developed by Just and Pope (1979) as starting values to gain the efficiency in the MLE estimation. If the error term in (20) follows a standard normal distribution with zero mean and unit variance, income is distributed as:

(21) $Y_t \sim N(\beta' X_t + d_1 \Phi_1(\hat{H}_1' X_1) + d_2 \Phi_2(\hat{H}_2' X_2) + d_3 \Phi(\hat{H}_3' X_3), g(.))$

Given equation (21), Saha, *et al*. (1997) show that the log likelihood function for equation (20) is:

$$(22)\ \log L = -\frac{1}{2}\left[n*\ln(2\pi) + \sum_{i=1}^{n} \log(g(.)) + \sum_{i=1}^{n} \frac{(y_t - \beta' X_t - d_1\Phi_1(\hat{H}_1' X_1) - d_2\Phi_2(\hat{H}_2' X_2) - d_3\Phi(\hat{H}_3 X_3))}{g(.)} \right].$$

The Data

The primary farm household data used in this paper are from the 2001 Agricultural Resource Management Survey (ARMS), conducted by the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA). By including data on the farm household (e.g. non-farm assets, non-farm income, demographics, etc.), the ARMS data provide the basis for assessing changes in the well being of farm households nationwide.

Since one of the primary objectives of this paper is to understand the participation decisions in CRP and off-farm work by farm households, we limit our attention to the sample of farm households, and we exclude some large corporate operations, etc. We also limit our attention to farms classified as crop farms. The lion’s share of CRP acreage is found on crop farms. A summary of the sample statistics for the variables used in this analysis is in Table 1.To gain some perspective on the nature of these combined decisions on the sample of farms, the frequencies of CRP participation and off-farm work by the operator and spouse are in Table 2.

Although the ARMS data base contains valuable information on the farm operation and farm household, it lacks information on land quality on the farm, local area economic characteristics, and certain aspects of the physical terrain, the quality of the area’s land base, or other conditions related to the environment that likely affect decisions to participate in the CRP and to work off the farm. To compensate for this lack of data, we also rely on some data from additional sources. The economic characteristics of local area, for example, are merged into our ARMS data set. These are county-level data 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 1990 Census of Population, STF-3 file. Three variables representing land quality at the county level in which the farm is located are also used. We define the land quality as the product of a variable reflecting the length of the growing season and the land capability class. (see Darwin and Ingram (2004) for details).

Another critical factor affecting CRP participation is the Environmental Benefits Index (EBI), which in part determines the maximum price that can be paid for land offered into the CRP. 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 approximate 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.

Empirical Results

In specifying the empirical models, we are guided by the theoretical results from above, as well as from previous literature (e.g. Goodwin and Mishra (2004) and El-Osta, *et al*. (2004)). We present the results of tests of the null hypothesis that the three decisions are independent. Next, we discuss the factors affecting the three decisions based on the estimated trivariate probit model. We then move onto a discussion of the estimated household income function.

Tests for Joint Decisions

To justify the use of this three-choice model, it is important to examine the estimated correlations between each pair of choices. From Table 3, the CRP participation decision is positively correlated with the off-farm work decisions of both the operator and the spouse, and the correlation coefficients are statistically significant. The highest of the three correlation coefficients is the one between the spouse's decision to work off the farm with the operator's decision to do the same (0.25).[8] The correlation between participation in CRP and the operator's off-farm work decision is also quite high (0.17). Thus, it is perhaps no surprise that there is also a positive correlation between participation in CRP and the spouse's decision to work off the farm, but the correlation is not as high (0.12). These results are strong evidence that these three decisions are made jointly, but to add further support, we test if the correlation coefficients are jointly equal to zero with the likelihood ratio test (LR).[9] This test is for the null hypothesis that these choices can be regarded as independent decisions. We reject the null hypothesis because the LR test statistic (53.8) is higher than the critical value (7.8) for a 5% level of significance.

Off-Farm Work Decision by the Farm Operator

The decision of the farm operator to engage in off-farm work depends on characteristics of the farm, the farm operator, and the circumstances in the local economy (Table 3). As in much of the existing literature (e.g. Sumner 1982; Benjamin and Guyomard 1994), our results continue to confirm the fact that older farmers (OP_AGE) are more likely to work off the farm.[10] However, the effect is nonlinear, with the likelihood of participation increasing with the operator's age up to about age 44, but declining thereafter. 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 (e.g. Mishra, *et al*. 2002), the indication that the

[8] Our findings are consistent with previous studies where there is evidence that decisions by farm couples to work off the farm are made jointly (Huffman and Lange 1989; Lim-Applegate, *et al*. 2002).

[9] The idea behind the test is that: if these decisions can be regarded as independent, the log-likelihood value of the trivariate probit model should be equal to the sum of the log-likelihoods of these three binary probit models under the null hypothesis. To implement the LR test, we estimated three independent binary probit models first and calculated the log-likelihood values for each. See Chang (2006) for details.

[10] 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.

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 is willing to accept more risk) is consistent with the theory of risk averse behavior.

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 than CRP may reflect wealth or scale effects on off-farm labor supply (e.g. Goodwin and Mishra, 2004).[11] 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 of participation in off-farm work. The extent to which the local economy depends on jobs in the trade (TRADE) sectors reduces the likelihood of participation in off-farm work.

Off-Farm Work Decision by the Spouse

The characteristics of the spouse, family and farm structure, and location also affect the choice of the spouse to work off the farm. Similar to the finding by the operator, the spouse who is older (SP_AGE) and more educated (SP_ED_C) is more likely to work off-farm, and the effect is nonlinear. We also find that the spouse’s farm experience (SP_EXP) decreases the likelihood of working off the farm, and the effect is statistically significant. This might well

[11] In interpreting this result, there is certainly reason to think that the decision to receive decoupled payments is also endogenous. It is not possible to include a fourth decision variable in this model, or even conduct a test of endogeneity. However, such a test is conducted by Chang (2006) in related research involving a two-choice model of CRP participation and off-farm work by the operator. Using tests developed by Smith and Blundell (1986) and Vella (1993), they test the null hypothesis that decoupled payments (AMTA_A) are exogenous to the off-farm work decision. They also test the null hypotheses that the decisions to be in an agricultural district (AGDIST) and receive decoupled payments (AMTA_A) are exogenous to the CRP participation decision. In all cases, they failed to reject the hypotheses that the corresponding decisions are exogenous.

reflect the opportunity cost of an off-farm job as was also apparent for the farm operator. Both results could also reflect a strong preference for farm work and a farm lifestyle. This logic would perhaps reinforce the negative effect of farm size (CROPSIZ1) on the probability of the spouse working off the farm. As the number of children under six years of age in the farm household (H_SIZE06) rises, the likelihood of the spouse working off the farm declines. As one would expect, it is during the years in which the children are young that the spouse will want to have more time at home with the young family. Finally, in areas where the local economies have a strong economic base, as reflected by a high proportion of employment in manufacturing (MANUF), the spouse is more likely to work off the farm, perhaps taking advantage of off-farm job opportunities that are relatively attractive compared with available jobs in areas that have a weaker economic base.

CRP Participation Decision

Participating in CRP depends generally on some characteristics of the farm, the farm operator, land quality, and the circumstances in the local economy. There are also some differences in participation by major ERS production region. 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 removing land from production of the relatively high-value crops on vegetable or nursery farms.

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. However, Parks and Schorr

(1997) argued that the maximum bid price ought to be one of the factors affecting CRP participation. We have no information on actual bids or bids accepted for our sample farms, but we do find that farm households that are located in areas where the EBI scores for land currently 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 related to the general quality of the soil resource in the region described above, participation in CRP rises (falls) as the proportion of land in the surrounding county is classified as high (LQH_96) (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. While this result does offer some guidance as to the types of areas where CRP participation is high or low, it offers little information about the quality of land that is actually enrolled in the program. We would need farm-specific information on land quality to draw further conclusions about the quality of land actually in the program.

There are two variables that suggest participation in CRP is related to 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 (an estimated correlation coefficient of 0.17) may also reflect a desire to reduce operator labor requirements as land is taken out of production, vice versa. 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. To the extent that these investments also lead to a greater appreciation by farmers of the value of the environmental benefits from CRP, these effects square with theoretical model above.

The risk attitudes of the farm operator also affect the propensity of the farm household to participate in CRP. As aversion to risk increases, we would expect that the likelihood of participation in a program where payments are certain, such as CRP, to 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, by allowing for decreasing absolute risk aversion (DARA), our theory 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 off-farm income opportunities as wealth increases through decoupled payments. However, it is difficult to know whether the attitudes toward risk are driving this result, or if it is also in part due to the fact that in order to receive decoupled payments farmers must continue to commit certain acreage to agricultural production even though land need not be committed to a specific crop. Finally, since commodity program-related loan deficiency payments (LDP_A) reduce farm income variability, these payments reduce risk averse farmers' concerns for allocating resources to programs, such as CRP.

Participation in other agriculturally-related 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.[12] 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 particularly venerable land from production, while at the same time using more environmentally friendly practices on land still in production.

Empirical Estimate of the Farm Household Income Function

The estimated farm household income function is reported in Table 4, where the mean and variance functions are specified in linear and exponential forms, respectively. The results of the income equation are quite encouraging, and the estimated coefficients are generally consistent with our theory and other a *priori* expectations.

In discussing these results, our initial interest in is identifying the extent to which decisions to participate in CRP and/or work off the farm affect both average farm household income and the variance in income across farms within the groups. These effects are embodied in the coefficients for the three variables that account for the endogenous treatment effects (the estimated probabilities of participating in CRP and working off the farm by the operator and spouse: PROB_CRP, PROB_OP, and PROB_SP, respectively).[13] As one might expect, household income rises with all three probabilities, although the effect of the probability of off farm work

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[12] Duke (2004) also found that the likelihood of participation in CRP is lower in highly urban areas.

[13] We perform a likelihood ratio test of the null hypothesis that the coefficients on the predicted probabilities specified in both the mean and variance functions are all zero. Our likelihood ratio test result (a chi-square value of 531) provides strong statistical evidence justifying their inclusion in the model. These probabilities, however, do affect the mean and variance in farm household income quite differently.

by the spouse is not statistically significant. One reasonable interpretation of the insignificant effect of this latter probability is that the spouse may work off the farm part time or primarily to gain access to health insurance from the employer, or to gain personal skills (Mishra, *et al.* 2002).

The interpretation of the variance function perhaps needs a bit of explanation. Since this variance function is based on a heteroskedastic error specification, it determines the extent to which the variability of household income across farm households is systematically related to farm and farm household characteristics, as well as the likelihood of participation in CRP or off farm work. Thus, all else equal, the variance in household income across farm households is systematically lower for those farm households which are more likely to participate in CRP or off-farm work (e.g. the negative coefficients on the variables PROB_CRP, PROB_OP, and PROB_SP in the variance equation of Table 4). These results on off-farm work square with those by Mishra, *et al.* (2002) and Mishra and Goodwin (1997) and suggest that off-farm income helps diversify sources of income. There is also less variability in household income among these farms with some off-farm income.[14] The fact that participation in off-farm work by the spouse reduces income variability among farms also squares with the fact that income variability is higher among those farms where the spouse is a home maker (SP_HMAK).

The performance of the human capital variables seem to be consistent with the standard results found in the human capital and earning literature (Low and Ormiston 1991). The operators who are retired from farming (OP_RET) are those with lower farm incomes, but incomes are less variable as well. As the experience of farm operators increase (OP_EXP), there is a tendency for average farm household income to be lower, but there is also less variability in incomes across farms in this group. This former result squares with the fact that farmers with

[14] While in our analysis CRP payments also seem to act to stabilize farm household income, we know of no other empirical studies that have attempted to establish this fact.

more experience are less likely to work off the farm or participate in CRP. However, while those farmers committed to farming may have somewhat lower average incomes, this latter result may speak to the value of farm experience in dealing effectively with the inherent variability of returns from farming. Furthermore, the characteristics of the spouses also affect household income. Household incomes increase with the spouses' educational levels (SP_ED_C), but incomes are more variable as the age of the spouse increases, all else equal.

The effects of the farm characteristics on farm household income are also consistent with expectations. Large farms (CROPSIZ1) or farmers who own a large share of their farmland (TENANCY) have higher farm household incomes. However, this probably means that a larger share of household income comes from farm sources—thus explaining, at least in part, why both of these variables contribute to the variability in household income across farms in the group. Perhaps consistent with these findings is that income variability is somewhat higher for those farms located in areas where there is a high proportion of high quality land (LQH_96). While these may be productive soils, yields may be more responsive to weather and other environmental factors at both extremes.

Farmers receiving decoupled payments (AMTA_A) also have higher average farm household incomes, which in part could be explained by the fact that decoupled payments are, in large measure, income transfers. Since, at most, decoupled payments would have only a modest effect on production decisions, it is not surprising that farm household income is less variable among households receiving them. The financial status of the farm household also determines the farm household income. As the debt to asset ratio rises (DEBT_RAT) average farm household falls, but not significantly so, but the variability of household income for farms with otherwise common characteristics falls, and the effect is significant.

Conclusions and Policy Implications

To better understand the interaction between the farm business and the farm household, we find evidence that the decisions of farm operators and their spouses to work off the farm are made jointly with the decision to participate in CRP. We also determine how these decisions interact with socio-economic characteristics of the farm and farm household to affect the well-being of farm households, as measured by farm household income, and its variability among farm households with common characteristics.

Participating in CRP depends on characteristics of the farm (including the type of farm), the farm operator (including age, experience, and attitudes to risk), land quality, and circumstances in the local economy. There are also some differences in participation by major ERS production region. Decisions to work off the farm by the farm operator and the spouse are related to many of these same factors, although the direction and magnitude of some of the effects are quite different. All three decisions are affected by participation in other Federal farm programs. Participation in CRP is affected by state and local programs for farmland retention, etc. Policy implications of these results are elaborated in the text.

It is not surprising that the decisions to participate in CRP and to work off the farm affect both average farm household income and its variability across farm households in which the other farm and household characteristics are similar. The nature of these relationships has important implications for farmers trying to adjust to a more market-oriented farm policy environment. For example, our results suggest that participation in CRP and off-farm work by both the operator and the spouse increase mean household income, but they decrease the variability of household income across household with other similar characteristics. These results would seem to square with our expectations, since income from both CRP and off-farm work is likely to be less variable than income from farm sources. The variability in household income among large farms or among farms in which a large share of farmland is owned is also higher. This situation is likely to persist in a more market-oriented farm policy environment because it is on these farms that a larger share of household income comes from farm sales.

References

Benjamin, C., and Guyomard, H. (1994). "Off-Farm Work Decisions of French Agricultural Households." In R. Caillavet., H. Guyomard., and R. Lifran (eds.). *Agricultural Household Modelling and Family Economics*: Amsterdam: Elsevier.

Bohrnstedt, G. and A. Goldberger. (1969). "On the Exact Covariance of Products of Random Variables." *Journal of the American Statistical Association* 64: 1439-1442.

Chang, H. (2006). "Economic Analysis of the Interrelationships Among Off-Farm Work, Participation in the Conservation Reserve Program, and Farm Productivity of Farm Households in the United States." Unpublished PhD Dissertation, Department of Applied Economics and Management, Cornell University, May.

Darwin, R. and K. Ingram. (2004). "A Global Land and Water Resource Database for Economic Models." *Economic Research Service Technical Bulletin.* Economic Research Service, United State Department of Agriculture, Washington, D.C.

Duke, J. M. (2004). "Participation in Agricultural Land Preservation Programs: Parcel Quality and a Complex Policy Environment." *Agricultural and Resource Economics Review* 33(1): 34-49.

El-Osta, H., A. Mishra, and M. Ahearn. (2004). "Labor Supply by Farm Operators Under "Decoupled" Farm Program Payments." *Review of the Economics of the Household* 2(4): 367-385.

Fabella, R.V. (1989). "Separability and Risk in the Static Household Production Model." *Southern Economic Journal* 55(4): 954-961.

Goodwin, B. K. and M. T. Holt (2002). "Parametric and Semi-Parametric Modeling of Off-Farm Labor Supply of Agrarian Households in Transition Bulgaria." *American Journal of Agricultural Economics* 84(1): 184-209.

Goodwin, B. K. and A. K. Mishra. (2004). "Farming Efficiency and the Determinants of Multiple Job Holding by Farm Operators." *American Journal of Agricultural Economics* 86(3): 722-729.

Gould, B. W. and W. E. Saupe (1989). "Off-Farm Labor Market Entry and Exit." *American Journal of Agricultural Economics* 71(4): 960-969.

Hallberg, M. C., J. L. Findeis, and D. A. Lass (eds.) (1991). *Multiple Job-Holding Among Farm Families*. Ames, Iowa: Iowa State University Press.

Hajivassiliou, V.A., D.L. McFadden, and P. Ruud. (1996). "Simulation of Multivariate Normal Rectangle Probabilities and Their Derivatives: Theoretical and Computational Results." *Journal of Econometrics* 72(1/2): 85-134.

Heckman, J. J. (1979). “Sample Selection Bias as a Specification Error.” *Econometrica* 47(1):153-161.

Huffman, W. E. (1991), Agricultural Household Models: Survey and Critique.” In M. C. Hallberg, J. L. Findeis., and D. A. Lass (eds.). *Multiple-Job Holding Among Farm Families*, Ames, IA: Iowa State University Press.

Huffman, W. E. and M. D. Lange (1989). “Off-Farm Work Decisions of Husbands and Wives: Joint Decision Making.” *Review of Economics and Statistics* 71(3): 471 -480.

Isik, M. (2002). “Resource Management Under Production and Output Price Uncertainty: Implication for Environmental Policy.” *American Journal of Agricultural Economics* 84(3): 557-571.

Jaroszewski, L. M. (2000). “Using a Land Allocation Model to Assess the Welfare Economic Implications of New York State's Conservation Reserve Enhancement Program.” Unpublished Master Thesis, Department of Applied Economics and Management, Cornell University, Ithaca, New York.

Just, R. E. and R. D. Pope (1979). "Production Function Estimation and Related Risk Considerations". *American Journal of Agricultural Economics.* 61:276-284.

Kimhi, A. (1994). “Quasi Maximum Likelihood Estimation of Multivariate Probit Models: Farm Couples' Labor Participation.” *American Journal of Agricultural Economics* 76(4): 828-835.

Kwon, C.W., P. Orazem., and D. Otto (2002). “The Determinants of Participation Decision in Off-Farm Work: The Iowa Case.” Paper Presented in *Annual Meeting of American Agricultural Economic Association*. Long Beach, California.

Hallberg, M. C., J. L. Findeis, and D. A. Lass (eds) (1991). *Multiple Job-Holding Among Farm Families*. Ames, Iowa: Iowa State University Press.

Lim-Applegate H., G. Rodriguez, and R. Olfert (2002). “Determinants of Non-farm Labour Participation Rates Among Farmers in Australia.” *Australia Journal of Agricultural and Resource Economics* 46(1): 85-98.

Low, S. A. and M. B. Ormiston (1991). “Stochastic Earnings Functions, Risk, and the Rate of Return to Schooling.” *Southern Economic Journal*. 57(4):1124-32.

McFadden, D.L. (1981). “Econometrics Models of Probabilistic Choice.” In Manski, C. F and D. L. McFadden (eds), *Structural Analysis of Discrete Data*: 198-272. Cambridge MA: MIT Press.

Mishra, A. and B. K. Goodwin (1997). "Farm Income Variability and the Supply of Off -Farm Labor." *American Journal of Agricultural Economics* 79(3): 880-887.

Mishra, A., H. S. El-Osta, M. J. Morehart, J.D. Johnson, and J. W. Hopkins (2002). "Income, Wealth, and the Economic Well-Being of Farm Households", Agricultural Economic Report 812, Economic Research Service, United State Department of Agriculture, Washington D.C.

Mullahy, J, and L. Sindelar. "Health, Income, and Risk Aversion: Assessing Some Welfare Costs of Alcoholism and Poor Health." *Journal of Human Resources* 30(3):439-458.

Offutt, S. (2002). "The Future of Farm Policy Analysis: A Household Perspective." *American Journal of Agricultural Economics* 84(5): 1189-1200.

Parks, P. J., and J. P. Schorr. (1997). "Sustaining Open Space Benefits in the Northeast: An Evaluation of the Conservation Reserve Program." *Journal of Environmental Economics and Management* 32(1): 85-94.

Saha, A., A. Havenner, and H. Talpaz (1997). "Stochastic Production Function Estimation: Small Sample Properties of ML Versus FGLS." *Applied Economics* (29): 459-69.

Smith, R.J., and R. W. Blundell. (1986). "An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply." *Econometrica* 54(3): 679-685.

Sumner, D. A. (1982). "The Labor Supply of Farmers." *American Journal of Agricultural Economics* 64(3): 449-509.

Train, K. E. (2003). *Discrete Choice Methods with Simulation*. Cambridge University Press.

Vella, F. (1993). "A Simple Estimation for Simultaneous Model with Censored Endogenous Regressors." *International Economic Review* 34(2): 441-457.

Vella, F., and M. Verbeek. (1999). "Estimating and Interpretating Models with Endogenous Treatment Effects." *Journal of Business and Economic Statistics* 17(4): 473-478.

Whittaker, G. W., and M. C. Ahearn. (1991). "Life Cycle and Expectations of Farmers." *Agricultural Income and Finance Situation and Outlook Report*. No. AFO-43. Economic Research Service, United State Department of Agriculture. Washington, D.C.

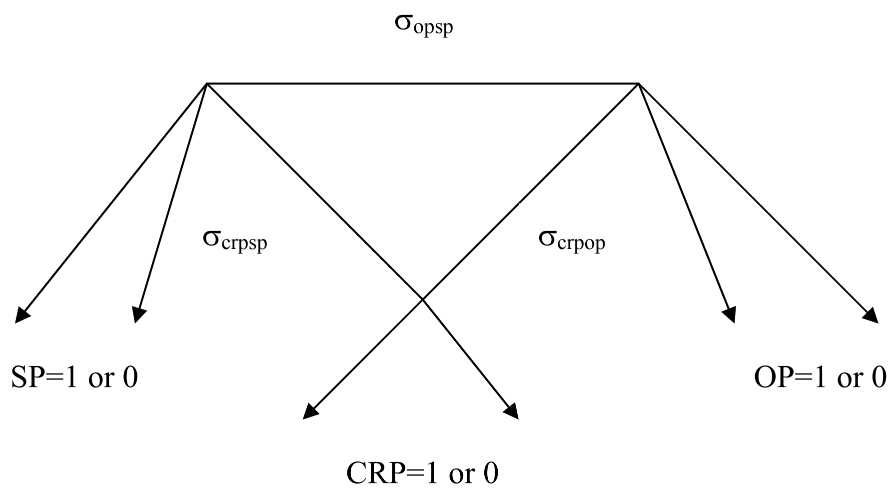

Figure 1: Trivariate Probit Model Specification

Table 1: Summary Statistics

Variable Names	Variable Definitions	Mean	Std.
Dependent Variables			
OP	If the operator worked off the farm (=1); otherwise (=0)	0.52	0.50
CRP	If the household enrolled in CRP or CREP (=1); otherwise (=0)	0.23	0.42
SP	If the spouse worked off the farm (=1); otherwise (=0)	0.57	0.50
INCOME	Total principle household income ($1,000)	67.98	106.82
Operator and Spouse Characteristics			
OP_AGE	Age of the operator	55.51	13.16
OP_RET	If the operator was retired (=1), otherwise (=0)	0.12	0.32
OP_ED_C	Education of the operator (year)	13.01	2.45
OP_EXP	Years the operator has worked on farm job	24.45	14.95
RISK	Risk preference rating of the operator; =1 if risk averse, 10 if risk loving	4.45	2.41
RAISE_OP	If the operator was raised on the farm (=1); otherwise (=0)	0.78	0.41
SP_AGE	Age of the spouse	53.43	12.84
SP_ED_C	Education of the spouse (year)	13.35	2.09
SP_EXP	Years the spouse has worked on farm job	24.45	14.95
RAISE_SP	If the spouse was raised on the farm (=1); otherwise (=0)	0.57	0.50
SP_HMAK	If the spouse is a home maker (=1); otherwise (=0)	0.27	0.44
Farm and Household Characteristics			
CROP17	If a cash grain farm, (=1),otherwise (=0)	0.69	0.46
CROP456	If a vegetable, fruit, or nursery farm, (=1),otherwise (=0)	0.22	0.42
NETWORT1	Household networth value ($100,000)	4.72	16.24
DEBT_RAT	Ratio of toal debt to total assets	0.13	0.22
NFASST1	Principle operator Household non-farm assets ($10,000)	13.96	22.49
TENANCY	Ratio of owned acres over total operated acres	0.96	2.10
AMTA_A	Per acre AMTA payment	5.38	12.73
LDP_A	Per acre LDP payment	8.37	19.16
CROPSIZ1	Operated acres (devided by 1,000)	0.33	0.70
H_SIZE	Number of household members	2.84	1.24
H_SIZE06	Number of children younger than 6 years of age	0.14	0.48

Table 1: Summary Statistics (con't)

Variable Names	Variable Definitions	Mean	Std.
Environmental Characteristics			
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)	0.0032	0.0566
EBI	Environmental benefit index	61.59	3.93
Locational and Local Economic Conditions			
URBAN	Percent of labor market area's population living in urban areas	56.51	21.86
MANUF	LMA's employment in manufacturing (%), lagged one year	13.78	6.89
TRADE	LMA's employment in wholesale and retail trade (%), lagged one year	20.30	2.34
AGDIST	If participates in local agricultural preservation program (=1); otherwise (=0)	0.04	0.20
REGN1	If located in Heartland (=1); otherwise (=0)	0.29	0.45
REGN3	If located in Northern Great Plains (=1); otherwise (=0)	0.07	0.25
REGN567	If located in Eastern Uplands, Southern Seaboard, or Fruitful Rim (=1); otherwise (=0)	0.30	0.46
REGN9	If located in Mississippi Portal (=1); otherwise (=0)	0.05	0.22

Data are from the 2001 ARMS Survey. Variables are weighted by the full sample weights; sample size is 2,102

Table 2: Sample Distribution of Three Joint Choices

Groups	CRP	OP	SP	Frequency	%
(1,1,1)	1	1	1	200	*9.51*
(1,1,0)	1	1	0	59	*2.81*
(1,0,1)	1	0	1	74	*3.52*
(1,0,0)	1	0	0	142	*6.76*
(0,1,1)	0	1	1	555	*26.40*
(0,1,0)	0	1	0	285	*13.56*
(0,0,1)	0	0	1	366	*17.41*
(0,0,0)	0	0	0	421	*20.03*
Total				2,102	*100*

Note: Weighted with full sample weights.

Table 3: Trivariate Probit Model Estimation

Variable	Coefficient	Std	t-value
	For OP Choice Equation		
Constant	-3.67	0.70	-5.26
OP_AGE	0.24	0.02	11.72
OP_AGESQ	-2.59	0.18	-14.18
OP_ED_C	0.06	0.01	4.39
OP_EXP	-0.05	0.01	-5.29
OP_EXPSQ	0.00	0.00	4.24
H_SIZE	0.00	0.03	-0.06
CROPSIZ1	-0.55	0.03	-17.43
RAISE_OP	-0.47	0.10	-4.56
MANUF	0.01	0.01	2.53
TRADE	-0.04	0.01	-3.04
AMTA_A	-0.01	0.00	-2.85
LDP_A	0.00	0.00	-1.07
RISK	-0.03	0.01	-1.70
NETWORT1	-0.01	0.00	-2.07
SP_HMAK	0.49	0.08	5.98
CROP456	-0.88	0.10	-8.91
REGN3	0.04	0.15	0.27
REGN567	-0.16	0.08	-2.04
TENANCY	-0.04	0.03	-1.60
	For CRP Choice Equation		
Constant	-5.70	1.48	-3.85
OP_AGE	0.03	0.00	9.57
OP_ED_C	0.08	0.02	4.85
LQH_96	0.54	0.23	2.35
LQL_96	-0.96	0.34	-2.79
EQIP	1.11	0.40	2.77
AGDIST	-1.18	0.26	-4.55
EBI	0.06	0.02	2.49
AMTA_A	-0.03	0.00	-5.92
LDP_A	-0.01	0.00	-5.24
RISK	-0.06	0.02	-3.14
CROP456	-1.96	0.26	-7.48
CROPSIZ1	0.23	0.04	5.56
REGN1	0.19	0.11	1.68
REGN567	-0.30	0.15	-2.03
REGN9	1.31	0.27	4.77
URBAN	-0.01	0.00	-7.45

Table 3: Trivariate Probit Model Estimation (con't)

Variable	Coefficient	Std. Dev.	t-value
	For SP Choice Equation		
Constant	-2.84	0.73	-3.89
SP_AGE	0.13	0.03	4.67
SP_AGESQ	0.00	0.00	-6.92
SP_ED_C	0.16	0.02	9.02
SP_EXP	-0.01	0.00	-1.88
H_SIZE	-0.10	0.03	-2.99
H_SIZE06	-0.26	0.09	-2.90
CROPSIZ1	-0.14	0.05	-2.60
RAISE_SP	0.14	0.07	1.94
MANUF	0.02	0.01	2.69
AMTA_A	0.00	0.00	-1.24
LDP_A	0.00	0.00	-0.39
NETWORT1	0.00	0.00	-0.99
CROP456	-0.88	0.09	-9.45
REGN3	0.14	0.17	0.86
REGN567	0.12	0.08	1.64
	Correlation Coefficients		
RHO(OP,CRP)	0.17	0.05	3.16
RHO(OP,SP)	0.25	0.05	5.28
RHO(CRP,SP)	0.12	0.06	2.00
Log-likelihood	-2792.44		
LR Test*	53.86		

**The null hypothesis is :RHO(OP,CRP) = RHO(OP,SP)= RHO(CRP,SP) = 0.*
The critical value is: (x^2 (0.95,3)=7.815)

Table 4: Estimated Stochastic Household Income Function

Variable	Coefficient	Std	t-value
	Mean Function		
Constant	0.24	20.07	0.01
OP_RET	-14.78	4.30	-3.44
OP_EXP	-0.28	0.15	-1.93
SP_AGE	-0.07	0.23	-0.32
SP_ED_C	4.29	0.83	5.16
CROPSIZ1	7.39	2.99	2.47
TENANCY	10.60	2.40	4.42
CROP17	-5.14	4.43	-1.16
AMTA_A	0.35	0.08	4.20
DEBT_RAT	-5.85	8.56	-0.68
URBAN	0.16	0.08	1.99
TRADE	-1.02	0.64	-1.58
REGN567	6.93	4.26	1.63
PROB_CRP	24.29	9.29	2.62
PROB_OP	18.40	9.95	1.85
PROB_SP	2.89	12.59	0.23
	Variance Function		
Constant	3.29	0.51	6.44
OP_RET	-1.02	0.14	-7.04
OP_EXP	-0.02	0.00	-5.75
SP_AGE	0.02	0.00	4.61
SP_HMAK	0.33	0.08	4.44
CROPSIZ1	0.18	0.03	6.30
TENANCY	0.20	0.02	10.28
AMTA_A	-0.01	0.00	-5.14
DEBT_RAT	0.22	0.06	3.74
NFASST1	0.02	0.00	18.68
LQH_96	0.26	0.15	1.79
URBAN	0.01	0.00	4.31
REGN567	0.17	0.08	2.13
PROB_CRP	-1.18	0.20	-5.78
PROB_OP	-0.28	0.20	-1.42
PROB_SP	-0.59	0.20	-2.90
σ	6.64		
Log L	-13,646		
LR Test*	531		

Note: PROB_CRP, PROB_OP,PROB_SP are predicted probabilities.

* The null hypothesis of the LR test is: prob_crp = prob_op = prob_sp = 0.

The critical value is: (x^2 (0.95,6)=12.59).