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OFF-FARM WORK DECISIONS OF HUSBANDS AND WIVES: JOINT DECISION MAKING

Wallace E. Huffman and Mark D. Lange*

Abstract—Theoretical and econometric models are developed to examine joint wage–labor participation and hours decisions of a husband and wife in farm households. The econometric model is multiple equation and recursive. The specification of the off-farm labor supply equation of the husband (wife) depends on whether his (her) wife (husband) does or does not work off-farm, and this structure is endogenous. The model is fitted to data for Iowa farm households. The main conclusion is that the off-farm labor supply equation of a married individual differs significantly depending on whether his or her spouse also works for a wage.

I. Introduction

EARLIER econometric studies of off-farm labor supply decisions of U.S. farmers (Huffman, 1980; Sumner, 1982) failed to consider the implications of non-negativity constraints on off-farm hours. Each time that a binding non-negativity constraint is encountered (e.g., the spouse does not work off-farm), the economic structure—some of the variables to be included and all the coefficients—of household decision functions are changed.

The objective of this paper is to propose and fit a recursive multiple equation econometric model of joint decisions for off-farm work of a husband and wife in farm households where endogenous switching of the econometric structure occurs whenever binding non-negativity constraints occur. The econometric model, which is adapted to take account of several serious problems that arise in implementing this procedure, is fitted to data for Iowa farm households. The main conclusion is that the off-farm labor-supply equations differ significantly depending on whether the spouse also works off-farm.

The paper has the following organization. Section II presents a model of time allocation where binding non-negativity constraints can occur. In section III, an econometric model of these decisions is described. Section IV presents the empirical results, and the final section presents a few implications.

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II. A Model of Time Allocation

The labor-supply decisions of husbands and wives in farm households are derived from a behavioral model that permits self-employment on their farms and wage work off-farm. For similar models, see Huffman (1980), Rosenzweig (1980), Sumner (1982), and Strauss (1986). The decision unit is a single-family farm household, and to simplify the analysis, the time allocations of only the husband (M) and wife (F) are considered. Husband's and wife's time are assumed to be heterogeneous. They receive an endowment of time each year ($\bar{T}$), which the household allocates among work on their farm (T_f), work off their farm (T_m), and to home time (T_h):

$$\bar{T} = T_f^i + T_m^i + T_h^i, T_m^i \geq 0; \qquad i = M, F. \quad (1)$$

Optimal hours of off-farm work may be zero in any year. The modeling takes explicit account of these inequality constraints on hours of wage work, which are important for proper empirical specifications of off-farm labor-supply functions.

The husband and wife work to obtain income for spending on consumption goods. The farm household is competitive in output and input markets and receives cash income from net farm income ($P_qQ - WX$), other household income (V), and possibly, income from off-farm wage work ($W^MT_m^M + W^FT_m^F$). Cash income is spent on consumption goods (Y):

$$W^MT_m^M + W^FT_m^F + P_qQ - WX + V = P_yY \quad (2)$$

where P_q is the price of farm output (Q), WX is the outlay on purchased farm inputs, and P_y is the price of Y. The off-farm wage rate net of commuting cost is $W^i = W^i(\tau)$, where τ represents distance to off-farm jobs. More generally, commuting expenses to off-farm work depend on the amount (days) of off-farm work.

The off-farm labor-demand or wage-offer equations facing husbands and wives are assumed to depend on their respective marketable human capital (E^i) and local labor market characteristics (ψ) but are assumed to be independent of their current hours of work. The market labor demand or off-farm wage functions are summarized in vector form as:

$$W^i(\tau) = W^i(E^i, \psi). \tag{3}$$

The expectation is that increasing marketable human skills (e.g., formal schooling, vocational training, and experience) shifts upward the labor demand curve. Restrictive land rental and ownership opportunities are expected to reduce labor mobility in rural labor markets and to affect wage offers.

The farm business is assumed to produce and sell farm output (Q). Variable inputs in farm production are husband's and wife's farm labor (T_f^M, T_f^F) and purchased inputs (X), including labor hired from other households. Farm family and hired farm labor are assumed to be heterogeneous because of different entrepreneurial skills and incentives to work. The efficiency of farm production depends on human capital of the husband and wife (E^M, E^F) and on other farm-specific characteristics (ϕ); e.g., climate. The technology of farm production is represented by the concave production function:

$$Q = Q\left(T_f^M, T_f^F, X; E^M, E^F, \phi\right). \tag{4}$$

The production function (4) is substituted into the income constraint (2) to obtain a new cash income constraint:

$$\begin{aligned} W^M T_m^M &+ W^F T_m^F \\ &+ P_q Q\left(T_f^M, T_f^F, X; \phi, E^M, E^F\right) \\ &- WX + V - P_y Y = 0. \end{aligned} \tag{5}$$

Household utility is assumed to depend on the inputs of home time of the husband and wife (T_h^M, T_h^F) and of goods purchased for direct or indirect consumption (Y):

$$\begin{aligned} U &= U\left(T_h^M, T_h^F, Y; E^M, E^F, \Gamma\right), \\ &\quad \partial U/\partial\Omega > 0,\ \partial^2 U/\partial\Omega^2 < 0, \\ \Omega &= T_h^M, T_h^F, Y. \end{aligned} \tag{6}$$

Household utility also depends on husband's and wife's human capital (E^M, E^F) because of efficiency or taste effects and other household characteristics (Γ) (e.g., number of children in the household, commuting distance to shopping, recreating, and schooling centers), which are not current choices.[1]

The key household decision or choice variables in this study are T_m^M and T_m^F, the amount of husband's and wife's time supplied to off-farm work, but these variables are determined *jointly* with X, T_f^M, T_f^F (or Q), T_h^M, T_h^F, and Y. The conditions for optimal decisions are obtained by maximizing equation (6) subject to resource constraints imposed by equations (1) and (5). Assuming an interior solution for all choices except T_m^i, the first-order conditions for a constrained maximum are:

$$\lambda\left[P_q Q_x - W\right] = 0 \tag{7}$$

$$\lambda P_q Q_{T_f^i} - \gamma^i = 0, \qquad i = M, F \tag{8}$$

$$\begin{aligned} &\lambda W^i(\delta) - \gamma^i \le 0, \\ &\qquad T_m^i > 0, T_m^i(\lambda W^i - \gamma^i) = 0; \\ &\qquad i = M, F \end{aligned} \tag{9}$$

$$U_{T_h^i} - \gamma^i = 0; \qquad i = M, F \tag{10}$$

$$U_y - \lambda P_y = 0 \tag{11}$$

$$\bar{T} - T_f^i - T_m^i - T_h^i = 0; \qquad i = M, F \tag{12}$$

and the budget constraint (5), where γ^i, $i = M, F$, and λ are Lagrange multipliers for marginal utility of husband's and wife's time and income, respectively, and U_j and Q_k are partial derivatives of the functions U and Q, respectively.

Equations (8)–(10) give conditions for optimal time allocation by a husband and wife. Both members are assumed to always have positive optimal hours of farm and home time; i.e., equations (8) and (10) are equalities. Equation (9) provides the optimality condition for off-farm work. If $W^i(\delta) < \gamma^i/\lambda$, then $T_m^{i*} = 0$, or optimal hours of off-farm work is zero. If $W^i(\delta) = \gamma^i/\lambda$, then an individual's off-farm wage, net of commuting cost, equals the marginal value of his (her) home time or farm labor, and optimal hours of off-farm work may be positive.

When an interior solution for T_m occurs, the off-farm wage $[W^i(\delta)]$ determines the marginal value of husband's and wife's time. Equations

[1] In this model, economic outcomes are certain. The introduction of risk-neutral attitude toward uncertainty into the model will not change the predictions of the model.

(7)–(9) are then the conditions for profit maximizing farm input usage, and they can be solved independently of the rest of the equations to obtain the demand function for farm inputs, including husband's and wife's farm labor:

$$\Omega = D_{f\Omega}\left(W^M, W^F, W, P_q, E^M, E^F, \phi\right);$$
$$\Omega = T_f^{M*}, T_f^{F*}, X^*. \tag{13}$$

To obtain the demand functions for husband's and wife's home time, equations (5), (10)–(12), conditional on (7)–(9), are required:

$$T_h^{i*} = D_{h_i}\left(W^M, W^F, \pi, P_y, V, E^M, E^F, \Gamma\right) \tag{14}$$

where $\pi = P_q Q^* - WX^* - W^M T_f^{M*} - W^F T_f^{F*}$. The off-farm labor-demand functions are derived residually. When the husband and wife both work off-farm:

$$\begin{aligned} T_m^{i*} &= \bar{T} - T_f^{i*} - T_h^{i*} \\ &= S_i\left(W^M, W^F, W, P_q, P_y,\right. \\ &\qquad \left. V, E^M, E^F, \phi, \Gamma\right); \qquad i = M, F. \end{aligned} \tag{15}$$

This equation is a source of evidence about own-wage effects and gross substitution or complementariness of husband's and wife's time in farm production and consumption.

When the non-negativity constraint is binding for either the husband or wife, the farm production decisions cannot be separated from household consumption and labor-supply decisions. Although off-farm labor supply continues to be derived residually, T_f^* and T_h^* contain the same variables. If for individual i, $T_m^{i*} = 0$, then for the spouse:

$$T_m^{j*} = S_j'\left(W^j, W, P_q, P_y, V, E^M, E^F, \phi, \Gamma\right), \qquad j = M, F. \tag{16}$$

When the husband does not work for a wage, W^M is not a determinant of the hours of off-farm work of his wife or of any of the other consumption or production decisions.

Selected comparative-static results are summarized. If home time is a normal good, an increase in household other income (V) shifts rightward the demand for T_h^i. For an off-farm work participant, his (her) farm hours remain unchanged. Thus, his (her) off-farm labor-supply curve is shifted leftward by an increase in V. If, however, the increase in home time is large, T_f^{i*} could be reduced to zero. For a nonparticipant, increases in T_h^{i*} are accompanied by an equal reduction in T_f^{i*}.

The wage elasticity of off-farm hours can be positive, negative, or zero. For a wage-work participant and T_h^i a normal good, an exogenous increase in the off-farm wage has two opposing effects on T_m^{i*}. A pure substitution effect, holding utility constant, decreases home time, but the income effect increases demand for home time. Thus, these two effects pull in opposite directions on off-farm hours. An exogenous rise in the wage rate of a wage-work participant is expected to reduce his (her) farm hours. For a nonparticipant, a rise in the off-farm wage rate increases the probability that he (she) becomes an off-farm work participant. The expected effects of accumulated human capital on off-farm and farm hours are generally a priori ambiguous. It may increase the efficiency of farm and (or) household production but more information is required about the nature of the change before predictions can be made. Strong effects empirically on farm, off-farm, and home hours might, however, be obtained.

III. The Econometric Model

The econometric model for husband's and wife's off-farm work contains a maximum of four structural equations—two labor market demand equations and two off-farm labor-supply equations. The model is recursive. Each market labor-demand equation contains only one endogenous variable, and the off-farm labor-supply equations contain two or more endogenous variables. This four-equation system is modified to permit structural changes caused by binding non-negativity constraints.

The econometric model is equations (17)–(19):

$$W^i = X^i\beta^i + v^i \text{ if } W^i > W^{iR}; \qquad i = M, F, \tag{17}$$

$$\begin{aligned} T_m^M &= W^M a_{11}^M + W^F a_{12}^M + Z\alpha^M + \mu^M, \\ &\qquad \text{if } W^M \geq W^{MR} \text{ and } W^F \geq W^{FR}; \\ T_m^M &= W^M a_{11}^{M*} + Z\alpha^{M*} + \mu^{M*}, \\ &\qquad \text{if } W^M \geq W^{MR} \text{ and } W^F < W^{FR}; \\ T_m^M &= 0 \text{ otherwise.} \end{aligned} \tag{18}$$

$$\begin{aligned} T_m^F &= W^M a_{21}^F + W^F a_{22}^F + Z\alpha^F + \mu^F, \\ &\qquad \text{if } W^M \geq W^{MR} \text{ and } W^F \geq W^{FR}; \\ T_m^F &= W^F a_{22}^{F*} + Z\alpha^{F*} + \mu^{F*}, \\ &\qquad \text{if } W^M < W^{MR} \text{ and } W^F \geq W^{FR}; \\ T_m^F &= 0 \text{ otherwise,} \end{aligned} \tag{19}$$

where W^i = hourly market wage rate of i ($i = M, F$); X^i = vector of personal (i^{th}) and local labor market characteristics; W^{iR} = reservation wage for i; Z = vector of nonwage variables that are exogenous to farm household consumption, production, and labor supply decisions; β^i, a^i_{jk}, α^i are unknown parameters; and v^i and μ^i are random disturbance terms.

The reservation wage for off-farm work of i is the marginal value of his (her) time when all of it is allocated to farm labor and home time (i.e., $\bar{T} = T^i_f + T^i_h$). Given equations (17)–(19), the equations for W^{iR} are

$$\begin{aligned} W^{iR} &= \left(1/a^i_{kk}\right)\left(X^j\beta^j a^i_{kl} + Z\alpha^i + \mu^i + v^j a^i_{kl}\right), \\ (i, j) &= \{(M, F), (F, M)\}, \\ (k, l) &= \{(1,2), (2,1)\}. \end{aligned} \tag{20}$$

Thus, the reservation wage of the wife is a function of the exogenous variables and random disturbance term of her husband's off-farm labor-demand equation and the nonwage exogenous variables and random disturbance entering her off-farm labor-supply equation.

The conditional nature of the different lines of equations (18)–(19) suggests that switching of structures is endogenous. If μ^i and v^j are normally distributed, then $\xi^i = (1/a^i_{kk})(\mu^i + v^j a^i_{kl})$, a new random disturbance, is normally distributed. Furthermore, ξ^F and ξ^M seem likely to be correlated because they contain common disturbance terms and are subjected to the same shocks. In this case, the probability of each structure can be represented by a bivariate probit model for off-farm work participation:

$$\begin{aligned} P_r[W^M \geq W^{MR}, W^F \geq W^{FR}] &= \rho_1\left(Z\Theta^M_1 + X\Theta^M_2, Z\Theta^F_1 + X\Theta^F_2, \delta\right) \\ &= \rho_1 \end{aligned} \tag{21}$$

$$\begin{aligned} P_r[W^M \geq W^{MR}, W^F < W^{FR}] &= \rho_2\left(Z\Theta^M_1 + X\Theta^M_2, Z\Theta^F_1 + X\Theta^F_2, \delta\right) \\ &= \rho_2 \end{aligned} \tag{22}$$

$$\begin{aligned} P_r[W^M < W^{MR}, W^F \geq W^{FR}] &= \rho_3\left(Z\Theta^M_1 + X\Theta^M_2, Z\Theta^F_1 + X\Theta^F_2, \delta\right) \\ &= \rho_3 \end{aligned} \tag{23}$$

where X contains all the variables of X^M and X^F, except ones included in Z, ρ_j's are bivariate normal distribution functions, and δ is the correlation coefficient.

Because of nonrandom econometric structures, the conditional mean values of the disturbance terms of the market labor demand (μ^i and μ^{i*}) and off-farm labor-supply functions (v^i) are potentially nonzero. If the means are nonzero, sample selection bias is a potential problem for equations (17)–(19). The potential problems with bias can be corrected by creating new variables that are conditional means of the disturbance terms and adding them to each equation (see Amemiya, 1974, p. 1010; Fishe et al., (1981), pp. 180–181).

The unconditional off-farm labor-supply equations are

$$\begin{aligned} T^M_m = {} & \left[W^M a^M_{11} + W^F a^F_{12} + Z\alpha^M + 1/\rho_1 \times\left(\eta^M_{11}S_{11} + \eta^M_{12}S_{12}\right)\right]\rho_1 \\ & + \left[W^M a^{M*}_{11} + Z\alpha^{M*} + 1/\rho_2\left(\eta^M_{21}S_{21} + \eta^M_{22}S_{22}\right)\right]\rho_2 \\ & + \epsilon^M, \quad \text{where } E\epsilon^M = 0 \end{aligned} \tag{24}$$

$$\begin{aligned} T^F_m = {} & \left[W^M a^F_{21} + W^F a^F_{22} + Z\alpha^F + 1/\rho_1\left(\eta^F_{11}S_{11} + \eta^F_{12}S_{12}\right)\right]\rho_1 \\ & + \left[W^F a^{F*}_{22} + Z\alpha^{F*} + 1/\rho_3\left(\eta^F_{31}S_{31} + \eta^F_{32}S_{32}\right)\right]\rho_3 \\ & + \epsilon^F, \end{aligned} \tag{25}$$

where $E\epsilon^F = 0$, and the conditional expectations of μ^M, μ^{M*}, μ^F, and μ^{F*} are

$$1/\rho_1\left(\eta^M_{11}S_{11} + \eta^M_{12}S_{12}\right),$$
$$1/\rho_2\left(\eta^M_{21}S_{21} + \eta^M_{22}S_{22}\right),$$
$$1/\rho_1\left(\eta^F_{11}S_{11} + \eta^F_{12}S_{12}\right),$$

and

$$1/\rho_3\left(\eta^F_{31}S_{31} + \eta^F_{32}S_{32}\right),$$

and ϵ^i are new random disturbance terms. Each expected conditional off-farm labor-supply equation has been weighted by its probability of occurrence (see Maddala, 1981).

Estimation of the multiple-equation endogenous switching econometric model (equations (17), (24), (25)), modified for sample selectivity, is made easier by its recursive structure. The market labor-demand equations can be fitted by least squares to observations on husbands and wives who participate in off-farm work. Although conditional off-farm labor-supply equations can be fitted to subsamples of observations that are matched to the structures, we choose to fit the unconditional equations (24) and (25) to the whole sample. The reason is few observations are available for fitting some of the structures relative to the number of parameters to be estimated and relative to the

TABLE 1.—MEANS OF VARIABLES—FARM HOUSEHOLDS AND OFF-FARM WORK, 1976

		Mean (S.D.)							
		Both work		Husband only		Wife only		Neither works	
Variables	Symbol	M	F	M	F	M	F	M	F
A. Endogenous									
Dummy off-farm work status	$D(OFF)^i$	1.0	1.0	1.0	0	0	1.0	0	0
Off-farm labor—annual hours	T_m^i	1,326	1,127	1,255	0	0	1,085	0	0
		(936)	(722)	(849)			(760)		
Off-farm wage—dollars/hour	W^i	5.85	4.59	6.08	—	—	7.76	—	—
		(3.01)	(5.52)	(2.88)			(20.33)		
B. Exogenous									
Age—years	AGE^i	41.1	39.2	44.7	42.5	45.3	42.3	49.9	47.0
		(10.6)	(10.3)	(12.0)	(12.4)	(11.6)	(11.1)	(12.9)	(13.1)
Education—yrs. formal schooling	E^i	12.5	12.5	11.7	11.8	11.8	12.7	11.1	12.0
		(2.1)	(1.7)	(2.3)	(1.7)	(2.2)	(2.1)	(2.2)	(1.9)
Dummy farm raised	$D(FRAISED)^i$	0.83	—	0.91	—	0.95	—	0.95	—
		(0.38)		(0.28)		(0.23)		(0.22)	
Asset income ($/yr.)	V	3,093		39,486		43,599		39,573	
		(302)		(225)		(213)		(167)	
Children: No. 6 yrs.	K_1	0.20		0.28		0.22		0.27	
		(0.55)		(0.56)		(0.50)		(0.62)	
No. 6–11 yrs.	K_2	0.57		0.67		0.41		0.48	
		(0.77)		(0.95)		(0.73)		(0.86)	
No. 12–18 yrs.	K_3	1.00		0.85		0.67		0.68	
		(1.13)		(1.12)		(1.01)		(1.05)	
Distance—miles to nearest city	$MCITY$	25.4		26.4		27.0		28.1	
		(17.8)		(15.6)		(14.4)		(13.8)	
Dummy region is West	$D(WEST)$	0.53		0.54		0.54		0.51	
		(0.50)		(0.50)		(0.50)		(0.50)	
Length growing season	GDD	2,966.7		2,922.0		2,958.9		2,957.9	
		(134.2)		(150.6)		(140.5)		(152.1)	
Sample size		60		93		112		506	

number of observations in other structures. Each individual i has a nonzero probability of being included in any of the four structures, and the additional observations can be helpful in identifying the parameters of the off-farm labor-supply equations (Maddala, 1981).[2]

IV. The Data and Empirical Results

The model of off-farm labor supply is to be fitted to data for a random sample of Iowa farm households collected in 1977.

The Data

The data for the analysis were obtained from a sample survey of Iowa farms and associated households. The population of farms included all farms having gross farm sales of $2,500 or more in 1976. The farm operator was identified as the primary decision maker for each farm business.[3] Husband–wife households from this survey provide the data for this study; they accounted for 92% of all survey households. Husbands allocated most of their time to farm work, and wives allocated most of their hours to home time. However, 65% of the wives reported some annual hours of farm work. Off-farm wage work was reported by 25% of the husbands and 28% of the wives.

The empirical definitions of the variables and summary statistics are reported in table 1. Off-farm wage work is measured in annual hours. Age (and age squared) control for nonlinear life cycle and work experience effects in labor demand functions and off-farm labor-supply equations.[4] Schooling is years of formal schooling completed. Being farm-raised reflects early on-the-job training, which may affect farming activity choices and opportunities

[2] Nelson (1984) has shown that multiple-step estimation procedures frequently have relatively low efficiency. Another route is to apply maximum likelihood estimation to equations (17)–(19). This is, in principle, possible but very expensive.

[3] Interviewers from ISU's Statistics Laboratory completed 933 questionnaires. The response rate was a relatively high 88%, and the Statistical Laboratory frequently called back households to obtain missing information and to verify information.

[4] Age squared for the husband and wife are highly correlated (0.98); so we squared only husband's age.

for obtaining land from relatives for farming. Asset income is interest on net worth in farmland and income from nonfarm assets.

Two location variables are included. Potential commuting distance is defined as the miles from the farm to the nearest city having a population ≥ 10,000. A dummy variable for location in the eastern versus western half of the state is included in the labor-demand equations. This variable summarizes differences in density of industrialization. A variable is added to labor-supply equations to represent the length of the normal crop-growing season, which increases from north to south. A longer growing season relaxes the constraint for timing of cropping activities and may increase the productivity of farm labor.[5]

Results

Off-Farm Work Participation: Bivariate probit estimates of the equations explaining off-farm work probabilities are reported in table 2. They are of direct interest because of insights into husband's and wife's joint off-farm work decisions and for constructing estimates of selection terms for the wage and hours equations. Although the correlation coefficient for the bivariate probit equations is positive, it is not significantly different from zero. Thus, two univariate probit estimations of the participation equations would also be appropriate.

The results show that the probability of off-farm work for husbands is greatest at a young age and tends to decline as they become older. For wives, there is a slightly concave life-cycle pattern. Increasing the wife's age, holding husband's age constant, has a positive and significant effect on his probability of off-farm work.

A husband or wife who has more schooling has a significantly greater probability of off-farm work than others. This implies that added schooling raises an individual's off-farm wage by more than it raises their reservation wage at farm and home activities. Our results for males are in contrast to Sumner's findings for Illinois farmers but in agreement with Huffman's (1980) results. Additional wife's schooling causes a reduction (significant) in the probability that her husband works off-farm; i.e., raises his reservation wage. Husbands who have early farming experience have lesser probabilities of off-farm work than ones raised elsewhere. His early farm background, however, has only a weak tendency to reduce his wife's probability of off-farm work.

[5] Acres operated and farm capital in machinery and livestock are excluded from the set of regressors because they are also household decision variables.

TABLE 2.—BIVARIATE PROBIT EXPLANATION OF OFF-FARM WORK STATUS, 1976 (ASYMPTOTIC t-RATIOS IN PARENTHESES, $n = 771$)

Variables	Husband Works Off-farm	Wife Works Off-farm
AGE^M	−0.045	0.025
	(1.11)	(0.64)
$(AGE^M)^2$	−0.025	−0.049
	(0.62)	(1.29)
AGE^F	0.050	−0.009
	(3.05)	(0.58)
E^M	0.088	0.026
	(3.19)	(0.98)
E^F	−0.091	0.080
	(2.96)	(2.76)
$D(FRAISED^M)$	−0.407	−0.186
	(1.82)	(0.97)
K_1	−0.256	−0.364
	(2.26)	(3.29)
K_2	0.008	−0.210
	(0.21)	(2.89)
K_3	0.043	−0.023
	(0.80)	(0.43)
ln V	−0.015	−0.009
	(1.43)	(0.92)
$MCITY$	−0.048	−0.032
	(3.47)	(2.39)
$MCITY^2$	0.071	0.048
	(3.17)	(2.22)
GDD	−0.075	0.003
	(1.92)	(0.08)
δ (correlation coefficient)	0.088	
(t-ratio)	(1.47)	
−2 ln (likelihood ratio)	146.5	

Children and the growing season affect the productivity of home and farm time. The presence of young children (< age 6) reduces the probability of a husband and wife working off-farm. Caring for young children is, therefore, more compatible with farm than off-farm work. Children ages 6–11 also reduce the probability that a wife works off-farm, but there is no effect on husband's off-farm work probability. Older children (ages 12–18) do not affect either parent's probability of off-farm work, suggesting no net effect on the reservation wage. A longer crop-growing season, which raises the marginal product of farm work, lowers the probability that the husband, but not wife, works off-farm.

Larger asset income tends to reduce the probability of off-farm work of the husband and wife, suggesting that home time is a normal good. Farm household members that are more isolated from jobs have a lower probability of off-farm work. Holding the off-farm wage constant, a longer commute to the nearest city reduces the net wage and has the expected negative and significant effect of reducing the probability that the husband and wife work off-farm. The negative effect of *MCITY* diminishes as distance increases.

Off-farm Labor-Demand Equations: Off-farm labor-demand equations for the husband and wife (equation 17) with sample selection terms included were fitted by least squares to all observations for which wage work was reported. The estimates of these equations (t-ratios in parentheses under coefficients) are

$$\begin{aligned}\ln W^M = {} & \underset{(2.03)}{0.769} + \underset{(2.50)}{0.059}\, E^M \\ & + \underset{(2.45)}{0.031}\, EXP^M - \underset{(2.70)}{0.0007}\,(EXP^M)^2 \\ & - \underset{(1.43)}{0.127}\, D(WEST) \\ & + \underset{(0.80)}{0.0022}\,(S_{11} + S_{21}) \\ & + \underset{(0.29)}{0.024}\,(S_{12} + S_{22}) + \hat{\mu}^M, \\ R^2 = {} & 0.27, \mathrm{df} = 147; \end{aligned} \tag{26}$$

$$\begin{aligned}\ln W^F = {} & \underset{(0.16)}{-0.117} + \underset{(1.65)}{0.079}\, E^F \\ & + \underset{(2.00)}{0.053}\, EXP^F \\ & - \underset{(1.97)}{0.0011}\,(EXP^F)^2 \\ & - \underset{(2.00)}{0.314}\, D(WEST) \\ & - \underset{(0.31)}{0.0016}\,(S_{11} + S_{31}) \\ & + \underset{(0.30)}{0.079}\,(S_{12} + S_{32}) + \hat{\mu}^F, \\ R^2 = {} & 0.07, \mathrm{df} = 166.^6 \end{aligned} \tag{27}$$

These results provide fairly standard education and experience effects on $\log_e$ wage. The results do, however, imply that a one-year increase in schooling causes a larger percentage (0.079 vs. 0.059) and absolute (0.44 vs. 0.35) increase for wives than for husbands. The results also imply that wives' wage-experience profiles are more concave than for husbands.[7] These are unusual male–female differences (Smith and Ward, 1984), but nonfarm females may spend a larger share of their worklife in wage work than farm males. Local labor market conditions affect labor demand. In the western region, males earn 12.7% less and females earn 31.4% less than in the east.

Off-farm Labor-Supply Equations: The unconditional off-farm labor supply equations ((24)–(25)) with sample selection terms included were fitted to all 771 sample observations. The wage rates were predicted from equations (26) and (27), and the probability of a particular conditional structure and sample selection variables (S_{ij}s) were derived from the bivariate probit estimates presented in table 2.

The off-farm labor supply equations were fitted by using Hoerl et al.'s (1975) version of the ridge estimator.[8] The ridge estimator was pursued because of extreme near multicollinearity. This is caused by the weighting scheme (same ρ_js) for all variables appearing in each conditional supply equation and by appearance of many of the same variables in the two conditional supply equations composing each unconditional supply equation except for different probability weights. Hoerl et al.'s (1975) procedure was employed, and stability of the ridge estimator was checked. Estimates of the ridge-K were shown to change by less than 0.1% for each 0.01 increment to K.[9] The t-ratios reported in table 3 are conditional on the predicted wage rates and sample selection terms. Other methods of computing t-ratios would give different values, perhaps smaller ones.

The algebraic form of the off-farm labor-supply equation is linear in hours and the natural logarithm of variables in dollar units. This specifica-

[6] The t-ratios are conditional on the predicted Ss. However, given that the coefficients of these variables are not individually or jointly statistically different from zero, this limitation is relatively unimportant. The joint tests resulted in sample F-values of 0.76 and 1.44 for equations (26) and (27); $F^{.05}_{2,125} = 3.07$.

[7] $Exp^i = AGE^i - E^i - 6$, which is a measure of potential experience.

[8] Least-squares estimates are available from the authors upon request.

[9] For the model, $\underset{\sim}{y} = X\underset{\sim}{\beta} + \mu$, the class of estimators defined by $\underset{\sim}{\beta}(K) = (X'X + KI)^{-1}X'\underset{\sim}{y}$ are called ridge estimators. The ridge scalar is K. The ridge estimator frequently has relatively good properties when near-multicollinearity is a problem (Vinod, 1978; Lin and Kmenta, 1982), but Vinod (1978) concluded that hypothesis tests may be affected by the bias of the estimator. The stability of the estimator is quite useful for estimating marginal effects.

TABLE 3.—"TWO STAGE" RIDGE-REGRESSION ESTIMATES OF UNCONDITIONAL OFF-FARM LABOR SUPPLY EQUATIONS, 1976
(PSEUDO t-RATIOS IN PARENTHESES, n = 771)

	Husband's Hours[a]		Wife's Hours[a]	
Variables	Both work	Husband only	Both work	Wife only
$\ln W^M$	121.39[b]	47.41	51.01	—
	(7.02)	(1.18)	(4.11)	
$\ln W^F$	105.86	—	61.03	−129.22
	(2.66)		(2.33)	(1.78)
AGE^M	0.545	0.782	0.108	−1.083
	(0.74)	(0.75)	(0.19)	(1.36)
$(AGE^M)^2$	−0.085	−0.020	−0.034	−0.030
	(2.90)	(0.65)	(1.57)	(1.42)
AGE^F	1.062	2.015	0.607	−0.295
	(1.15)	(1.60)	(0.92)	(0.33)
E^M	17.186	2.687	7.383	0.564
	(4.79)	(0.380)	(3.01)	(0.11)
E^F	7.505	−2.713	12.140	−9.212
	(2.36)	(0.34)	(5.44)	(1.87)
$D(FRAISED^M)$	−178.15	71.34	71.52	21.03
	(2.23)	(0.67)	(1.18)	(0.28)
K_1	−61.58	391.65	−126.66	52.67
	(0.49)	(4.04)	(1.28)	(0.70)
K_2	75.72	−19.78	−69.25	−8.06
	(1.29)	(0.38)	(1.48)	(0.20)
K_3	64.73	59.01	−13.72	−2.81
	(1.76)	(1.22)	(0.48)	(0.07)
$MCITY$	−1.890	−1.974	1.293	0.230
	(1.44)	(0.84)	(1.27)	(0.13)
$MCITY^2$	−0.028	0.006	−0.007	−0.051
	(1.17)	(0.10)	(0.36)	(1.06)
$\ln V$	3.014	5.473	−7.785	−8.622
	(0.46)	(0.54)	(1.57)	(1.11)
GDD	0.074	0.049	0.039	0.003
	(5.40)	(2.22)	(4.13)	(0.19)
S_{11}	-0.64×10^{-3}		-1.00×10^{-3}	
	(0.70)		(1.45)	
S_{12}	-0.16×10^{-3}		0.25×10^{-3}	
	(0.71)		(1.46)	
S_{21}	0.23×10^{-3}			
	(0.27)			
S_{22}	0.22×10^{-3}			
	(1.17)			
S_{31}			-0.14×10^{-2}	
			(1.13)	
S_{32}			0.94×10^{-4}	
			(0.36)	
Intercept	−4.102		252.94	
	(0.08)		(5.28)	
R^2	0.14		0.09	
Ridge K	0.30		0.44	

[a] Each of the variables except for the selection terms (Ss) are weighted by a probability, ρ_i, i = 1, 2 or 3.
[b] t-ratios are conditional on predicted values of wage rates and selection variables.

tion has been used by others; e.g., Schultz (1980). It performed marginally better here than one with log hours, and it has the reasonable implication that the wage elasticity of off-farm labor supply decreases as off-farm hours increase. The most significant result presented in table 3 is the evidence that the economic structures are different when inequality constraints are encountered. A joint test of equality of all coefficients variable-by-variable appearing in the two structures, except for wage and sample selection terms, was rejected at the 1% significance level.[10] Thus, earlier off-

[10] The sample F-values are 2.96 and 3.12 for the joint tests in the husbands and wife's equations; $F^{.05}_{13,737} = 1.77$.

farm labor-supply studies (e.g., Sumner, 1982; Rosenzweig, 1980) that failed to take account of this heterogeneity contained potentially serious specification errors.

Own-wage elasticities are larger when both adults work off-farm than when only one works. Evaluated at the subsample means, the own-wage off-farm labor-supply elasticity for husbands is 0.091 when the husband and wife both work off-farm and 0.038 when only he works off-farm. For wives, the own-wage labor-supply elasticities are 0.054 when they both work off-farm and -0.119 when only she works off-farm.[11] Our wage elasticities for husbands or farm operators are substantially smaller than Sumner (1982) obtained.

Cross-wage elasticity estimates show that husband's and wife's time are gross complements. Asset-income effects on female off-farm labor supply are negative, implying that female home time is a normal good. Although these results are statistically weak, they are stronger than the asset-income effects on male off-farm labor supply.

The effects of education differ by structure. When the husband and wife both work off-farm, all the own- and cross-person education effects are positive and significant. However, when only the husband works, neither education coefficient has a significant effect. When only the wife works off-farm, the sign of the coefficient on her education becomes negative in her off-farm hours equation, and her spouse's education has no significant effect.

Children and growing season affect off-farm hours differently than participation. When the husband and wife work off-farm, additional young ($<$ age 6) children tend to reduce off-farm hours, but the effect is statistically weak. When only one of the parents works off-farm, additional young children tend to increase off-farm hours. Off-farm hours by wives tend to be reduced by a larger number of children ages 6–11 and ages 12–18. A longer crop-growing season increases husband's off-farm hours. When off-farm work occurs, the longer season seems to facilitate flexibility of farm work, leaving more time for off-farm work.

Other effects follow: A slightly concave life-cycle profile of hours exists except when only the wife works off-farm. *MCITY* has its effects primarily on probability of participation and not on hours, given participation. Sample selection terms ($S_{ij}s$) are not individually or jointly significantly different from zero.[12]

V. Implications

Multiple binding non-negativity constraints are reasonably common phenomena. They may arise whenever joint decisions are being made by economic agents. In agriculture, farmers make decisions on multiple outputs, and in a sample of farms, a significant share of them will be against non-negativity constraints for two or more outputs. In nonfarm households, multiple binding non-negativity constraints occur when husband's and wife's labor-supply decisions are considered jointly with demand decisions for goods. These complexities are, however, seldom explicitly incorporated into econometric models.

Our experience may be useful to others. We encountered several problems when we implemented an econometric model adapted for two binding non-negativity constraints. When conditional off-farm supply equations were fitted by least squares to subsamples, some subsample sizes were small, and t-ratios for estimated coefficients were generally small. When an unconditional supply equation was adopted, it suffered from near-multicollinearity. Finally, a maximum likelihood estimator for the system is expensive to obtain. These are all problems that other researchers might expect to encounter when they attempt to econometrically model multiple binding non-negativity constraints.

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[11] An estimate of the unconditional population response of husband's off-farm labor supply to a one-unit change in Z_j is $\rho_1\alpha_j^M + \rho_2\alpha_j^{M*}$.

[12] The sample F-values are 0.73 and 1.12 for the joint tests in the husband's and wife's equations; $F_{4,737}^{.05} = 2.39$.

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