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Farm Household Production: Demand for Wife's Labor, Capital Services and the Capital-Labor Ratio

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The application of the concept of household production, where goods and household labor are transformed within the household into commodities or home goods, has been the subject of wide-ranging theoretical developments. However, most empirical studies have concentrated on labor supply aspects of time allocation and most researchers have not distinguished between leisure and work at home. Gronau (1977), however, is an exception. The distinction between leisure and household labor becomes important when nonwage or nonincome time is the focus of analysis. It seems unlikely that the household utility (or production) function is weakly separable in a form that permits aggregating leisure and household labor into a composite good. Furthermore, empirical studies that concentrate solely on human-time allocation are missing an important aspect of household resource allocation, the possible substitution of capital services for household labor. Very little is known about substitution between household members' time and goods in household production. The single published empirical study of capital-labor ratios in household production is by Bryant (1976).

Keith Bryant's data are from the farm part of the Rural Income Maintenance Experiment on Iowa and North Carolina low-income rural households. His capital-labor ratio is the dollar value of the stock of consumer durables divided by the wife's annual hours of hometime. Both of these empirical measures have major deficiencies. First, the use of current dollar value of a household's stock of durable goods overlooks two salient points. Households purchase capital goods primarily to acquire the services of these goods. The value of the stream of services from the capital goods would be measured in a well functioning rental market as the (annual) rental, or it can be represented in its absence as a function of the rate of interest, rate of depreciation, and the original purchase price of the durable good. The depreciation

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rate differs across goods because of differences in the expected useful lifespans. Goods of a given type also have different ages and hence differ in quantity of remaining services. Thus, even if one assumes the same interhousehold opportunity cost of capital (interest rate), the value of the stream of services from household capital goods will not be the same fixed proportion of the current value of the stock for all households. These differences may cause significant interhousehold variation in the relationship between stocks and flows. Furthermore, if education of the wife and (or) husband have a systematic effect on household managerial efficiency, and hence on absolute and perhaps relative factor usage in household production, then these effects may not be captured in a current-value stock measure of household capital. Second, Bryant measures hometime of the wife as an aggregate of her household labor and leisure. Thus, changes in the household capital-labor ratio (using hometime in the denominator) is meaningless for giving a perspective on what is happening to capital services relative to wife's household labor. Wife's household labor generally reacts to changes in economic variables in the opposite direction as her leisure time. Moreover, Bryant reports only estimates of the capital-labor ratio equation and not of the wife's household labor or capital equations. Thus, the source (human time or capital) of the reaction of household capital-labor ratios to economic variables is unknown.

Our paper presents a model of farm household resource allocation and econometric estimates of equations explaining absolute and relative factor intensities of household production. The households that we model have a self-employed farm business and the possibility of off-farm wage work. Demand functions for wife's household labor, for capital services from household appliances and housing, and for the household capital-labor ratio are fitted to mirco-household data from a 1977 survey of Iowa households. An estimate of the demand function for wife's leisure is included to show the dramatic response difference between wife's household time and leisure.

Section one presents a theoretical model of household resource allocation. Section two contains a discussion of the data set, the econometric model and empirical definitions of the variables. The results are presented in section three, and section four contains the conclusions.

I. A Theoretical Model of Household Resource Allocation

The households we model have a self-employed farm business, as well as the possibility of wage work. Our model then differs from the standard ones applied to wage earning households or other published models of farm household behavior, e.g., Rosenziweig (1980). Bryant (1976) and Evenson (1978) have presented models where leisure time and household production are nonjoint. In our model, we assume that household production is an important activity (and similar to farm production) and that farm and household production may be joint.

Pollak and Wachter (1975) have argued that household production itself seems likely to be joint and that this jointness should be taken into account in deriving theoretical and empirical models of household behavior. In general, for farm households, the possibilities for joint production are much greater than for wage earning households.

The decision unit in our model is assumed to be the single-family farm household. To explain resource allocation, farm households are assumed to behave as if they attempt to maximize household utility subject to constraints on human time, income, and a joint farm-household production function. The household utility function is assumed to be a monotone twice-continuously differentiable, strictly concave function:

(1) $U = U(Y_H, T_{1L}, T_{2L})$

where Y_H is household output, or home goods, and T_{1L} and T_{2L} represent the leisure time of the husband and wife, respectively. To simplify the analysis, only human time endowments of the husband and wife are considered as choices. The vector of time endowments is assumed to be allocated to four uses:

(2) $T = T_F + T_W + T_H + T_L$

where T_F is farm labor, T_W is nonfarm wage labor, T_H is house labor, and T_L is leisure. House labor is considered to be work, and it does not include time allocated to recreation, vacations, and charitable or civic activities. Time allocated to the latter activities is included in leisure time.

The technology of joint farm-household production is represented by the twice continuously differentiable, strictly concave asymmetric transformation function:

(3) $Y_F = G(Y_H, T_H, T_F, X, \gamma) \geq 0,$

where Y_F is net farm output and Y_H is home goods. T_H is the vector of husband's and wife's household labor, T_F is a vector of husband's and wife's farm labor, X is a vector of purchased inputs for household and farm production, and γ is a vector of environmental and fixed inputs. The environmental inputs include variables that affect the efficiency of transforming inputs into outputs. The variables include age (experience) and education levels of the husband and wife and the number (stock) of children at home by age.

The household receives income from off-farm wage work of the husband and wife, sale of net farm output and other nonfarm nonwage income and it is spent on purchased inputs for household and farm production:

(4) $W\,T_W + P_F Y_F + V - P_X\,X \geq o$

where W is a vector of off-farm wage rates for the husband and wife. We assume spouses' off-farm wage rates are exogenous to their current off-farm work decision and that available off-farm work hours are flexible. The price P_F is the exogenous price of farm output, V is nonfarm nonwage income, and P_X is a vector of exogenous input prices. If we solve for T_W is equation (2), substitute into equation (4) and rearrange, the farm household full-income constraint is:

(5) $R = W\ T + P_F Y_F + V - W(T_F + T_H + T_L) - P_X X \geq 0.$

The Lagrangean equation for maximization of household utility (1), subject to the transformation function (3) and full income (5) is:

(6) $\Psi = U(Y_H, T_{1L}, T_{2L}) + \lambda_1[Y_F - G(Y_H, T_H, T_F, X, \gamma)]$

$+ \lambda_2[WT + P_F, Y_F + V - W(T_F + T_H + T_L) - P_X X].$

It is well known that models of optimizing households are useful for suggesting the parameters that should explain choices. Assuming that the elements of γ are not household choice variables, the first-order conditions give a set of structural equations that can be solved (locally) for household decision rules, the demand and supply equations:

(7) $Z = Z(W, P_F, P_X, V, \gamma),\ Z = T_L, T_H, T_F, T_W, X, Y_F.$

It is also well known that these models provide relatively few comparative static results that can be compared directly to signs of estimated coefficients of the stochastic version of the demand and supply equations. The reason is that estimated price effects contain both pure price and pure income effects, and at most only the sign of the pure price effect is known *a priori*.

II. The Data Set, Econometric Model, and Variables

The data are from an area probability sample of the population of all Iowa farms having gross sales in 1976 of at least $2,500 (Hoiberg and Huffman, 1978). The data were collected by personal interviews of 933 households. The survey provides information on a wide variety of household and farm characteristics, including the annual hours of house work, farm work, and wage work for husbands and wives; the ownership of household appliances; and the characteristics of housing. Our survey data have major advantages over alternative available data sets. First, the survey asked specifically about the allocation of time to house work, farm work and wage work, rather than to only farm work and off-farm work. Second, the survey asked specifically about off-farm wage hours, rather than aggregating off-farm wage and off-farm self-employment days together, which is the method of the U.S. Census of Agriculture. Third, the survey asked about characteristics of housing and ownership of household appliances. Fourth, the Iowa survey data are from a random sample of a broadly defined population of farm households. Other farm household samples are samples of low income (and otherwise not randomly selected) households, e.g., the farm households of the Rural Income Maintenance Experiment.

For the empirical model, we propose one general model that can be fitted to data for all farm households. By using the whole sample, we can explain a broader range of behavior, minimize the problems of sample selection bias, and provide empirical results that can be generalized with confidence. Our approach is in contrast to Bryant's (1976). He grouped farm households by whether the husband or wife reported farm work and (or) off-farm work, and then he fitted household capital-labor ratio equations to each of these groups separately. The problem is that households are not randomly assigned to each of the groups. Both variables observed by the researcher and variables known to respondents but unknown to the research determine the allocation of households among the groups. Thus, the empirical results from Bryant's grouped data are difficult to interpret and generalizations are with much trepidation. We construct an econometric model that permits us to use the whole sample to fit household demand equations for wife's leisure, wife's household labor, and household capital services.

The econometric model is:

(8)-(10) $T_{2j} = \beta_1^j \ell nW_1 + \beta_2^j \ell nW_2 + Z_3\beta_3^j + \beta_4 X_H^j + \varepsilon_{2j} = L, H, W$

(11) $X_H = \gamma_1 \ell nW_1 + \gamma_2 \ell nW_2 + Z_3\gamma_3 + \gamma_4 T_{2j} + \varepsilon_x$

(12) $T_{1W} = \delta_1 \ell n W_1 + \delta_2 \ell n W_2 + Z_3\delta_3 + \varepsilon_{1W}$,

(13)-(14) $\ell n W_k^o = Z_k\alpha_k + \mu_k$, $k = 1, 2$,

(15) $I_{1i} = \begin{cases} 1 \text{ iff } \nu_{1i} > -N_{1i}\beta_1^* \\ 0 \text{ iff } \nu_{1i} \leq -N_{1i}\beta_1^* \end{cases}$

i = household index

(16) $I_{2i} = \begin{cases} 1 \text{ iff } \nu_{2i} > -N_{2i}\beta_2^* \\ 0 \text{ iff } \nu_{2i} \leq -N_{2i}\beta_2^* \end{cases}$

(17) $\ell n W_1^o = Z_1\alpha_1^* + \eta_1(1 - N_1\hat{\beta}_2^*) + \mu_1^*$,

(18) $\ell n W_2^o = Z_2\alpha_2^* + \eta_2(1 - N_2\hat{\beta}_2^*) + \mu_2^*$,

where ε_{2L}, ε_{2H}, ε_{2W}, ε_X, ε_{1W}, μ_1, μ_2, ν_1, ν_2, μ_1^*, μ_2^* are vectors of random disturbances. The random disturbances of equations (8)-(12), (15) and (16) are assumed to be independent, identically normally distributed with zero mean and constant variance. Equations (8)-(12) are the household demand equations for wife's leisure (T_{2L}) and household labor (T_{2H}) and supply of wife's off-farm wage labor (T_{2W}). Equation (11) is the household demand equation for household capital services, and equation (12) is the household's supply of husband's off-farm wage labor (T_{1W}). The vector Z_3 in these demand and supply equations contains nonwage explanatory variables, including other household income, farm acres, age and schooling of the husband and wife, and number of children at home by age group.

Equations (13)-(14) are the off-farm wage-offer equations of the husband and wife, respectively; Z_k is a vector of individual and market characteristics that determines the individual's market wage, e.g., schooling and experience. Off-farm wage data are available, however, only for husbands and wives that choose to participate in off-farm wage work, or when an individual's off-farm wage offer exceeds her reservation wage. An off-farm wage rate is observed for the wife (husband) in the i-th household if her (his) off-farm participation index I_{2i} of equation (16) [I_{1i} of equation (15)] equals one, i.e., the random disturbance ν_{2i} (ν_{1i}) exceeds the systematic relationship $-N_{2i}\beta_2$ ($-N_{1i}\beta_1$), where N_1 and N_2 contain all the explanatory variables included in the vectors Z_1, Z_2, and Z_3.

The problem with using a wives' (husbands') wage equation that has been fitted to wives (husbands) who reported off-farm wage work to predict the shadow wage for all wives (husbands) is that off-farm wage-work participation is not assigned randomly across husbands and wives (Heckman 1979). To attempt to correct this problem, the predicted probability of an individual not participating in off-farm wage work [$(1 - N_{ki}\beta_k^*)$, k = 1, 2] is added as an explanatory variable to the modified wage equations (17)-(18). (See Olsen 1980). The random disturbances μ_1^* and μ_2^* of equations (17)-(18) have zero mean but are heteroschedastic.

In this paper, we do not estimate all of the equations (8)-(18). Equations (15)-(18) are estimated to obtain shadow wage data for all husbands and wives, irrespective of their off-farm wage work decision. Equations (10), (12)-(14) are not estimated, and equations (8), (9), and (11) are the main focus of our empirical analysis.

The sample households for this paper are the Iowa survey farm households in which a husband and wife are present and in which complete data on relevant variables are reported. Husbands and wives were asked by interviewers to give retrospective information for a calendar year on the amount of time that they spent working on their farm, working off their farm for a wage, and working around the house. See Table 1 for the exact definition of these and other variables used in this study. As an aid in recalling this information, the calendar year was split into four seasons, and each respondent was asked first to give the number of days that they worked during a season and the average number of hours worked per day. Because working time was to be allocated to three broadly defined nonoverlapping categories, the time seems to be allocated fairly accurately to each category by the respondents.

Leisure time is defined as a residual. For a spouse, leisure is defined as 6205 hours less total annual reported hours for farm work, off-farm work for a wage, and house work for each individual. In arriving at 6205 annual hours of available time, personal-care time of 7 hours per day was first subtracted from the maximum total annual hours of 8760. The reason for deducting time for personal care is that personal-care time seems to be insensitive to changes in socioeconomic variables (Ghez and Becker 1975).

The empirical definition of basic household capital services is the annual rental value of the services from household appliances and housing. The Iowa survey listed twenty primary nonrecreational household appliances to which respondents were to indicate ownership. Capital services from these household appliances are derived as:

$$(19) \quad X_H^A = \sum_{i=1}^{20} P_i(r + d_i)$$

where P_i = market price of i-th durable good when "new" indexed to 1972 = 100, r = rate of interest, and d_i = depreciation rate of i-th durable good. Market prices of new durable goods are derived as average prices from Sears and Montgomery Ward catalogs of the appropriate year. Average ages of appliances were not established in the survey, so a uniform age distribution was assumed on expected lifespans of appliances (K. Tippett 1978). For example, an automatic clothes washer has an expected lifespan of 11 years, average age of 6 years, and the appropriate catalog year was 1970. Due to the relatively larger search costs for farm households, as opposed to urban dwellers, catalog prices seem warranted.

The rate of interest is set at 0.07. The estimated rate of depreciation is a simple straight-line rate based on the expected useful lifespans, the reciprocal of the expected lifespan (see Appendix A).

Housing is included in our capital service measure because some of the characteristics of housing reduce household labor requirements, i.e., automatic central heat, running water, indoor plumbing, and others increase labor requirements, i.e., larger size and number of rooms. Households were asked to provide an estimate of the monthly rental for their house. However, very few of the households actually pay a cash rental. Most own their own house or rent a farm that includes a house. Thus, about 50 households could not provide an estimate of a monthly rental for their house, but they did provide data on the characteristics of their house. To avoid losing these observations from our labor and capital services equations, and to take advantage of the information they provided, we chose to fit the reported rental rates to the characteristics of the house in a hedonic regression (Kain and Quigley 1970, Ball 1973), and then we employ the predicted values from this regression equation as the monthly housing rental for all households. Our measure of household capital services is then the imputed annual rental on the 20 household appliances and on housing.

$$
\begin{aligned}
(2)\quad \text{Rent} = {} & \underset{(8.73)}{213.88} - \underset{(-6.66)}{1.83}\text{HAGE} + \underset{(3.80)}{0.009}\ \text{HAGE}^2 + \underset{(2.97)}{16.76}\text{ROOMS} \\
& - \underset{(-1.66)}{0.517}\text{ROOMS}^2 - \underset{(-6.86)}{3.12}\text{MCITY} + \underset{(4.71)}{0.039}\text{MCITY}^2 - \underset{(-5.69)}{2.06}\text{MSMSA} \\
& + \underset{(4.49)}{0.015}\text{MSMSA}^2 + \underset{(3.98)}{20.42}D_1 + \underset{(3.20)}{11.87}D_2 + \underset{(3.10)}{16.7}D_3 \\
& - \underset{(-4.16)}{80.6}D_4 + \hat{u} \qquad N = 766 \quad R^2 = .475
\end{aligned}
$$

Two estimates of the farm-family household income are derived from the survey data. They are permanent nonfarm nonwage income and permanent farm income. The permanent nonfarm nonwage income, hereafter called permanent other income, is an estimate of a flow of income from the net value of the nonfarm assets of the household (stocks, bonds, nonfarm business). It does not include transfer payments and welfare assistance. Permanent farm income is an estimate of the permanent cash rental on the household's equity in farmland. This permanent farm-income measure does not include returns to livestock and farm machinery.

The estimated wage offer equations for the husband and wife are of a semi-$\log_e$ functional form in a fairly standard set of variables (Mincer 1974, Heckman and Polachek 1974) and the sample selection term. In addition to an individual's education and experience, we include in these equations two dummy variables, one for possession of market oriented vocational training and a second for their geographical location (west vs. east) in the state. The rationale for the geographical dummy is that the density of industrialization is much lower in the western than in the eastern half of the state and this difference might affect wage offers. The estimated wage offer equations (t-ratios in parentheses) for the husband and wife, respectively are:

$$\text{(21)} \quad \widehat{\ln W_1^o} = \underset{}{0.057} + \underset{(2.52)}{0.06ED_1} + \underset{(2.30)}{0.03EX_1} - \underset{(-2.5)}{0.0007EX_1^2} - \underset{(-0.55)}{0.075D(MVT_1)}$$

$$- \underset{(-1.70)}{0.293\,(1 - N_1\hat{\beta}_1)} - \underset{(-0.81)}{0.086R_{WEST}} \qquad R^2 = .17 \quad \text{sample size - 162}$$

$$\text{(22)} \quad \widehat{\ln W_2^o} = 0.114 + \underset{(1.90)}{0.090ED_2} + \underset{(2.78)}{0.218EX_2} + \underset{(2.54)}{0.023EX_2^2} - \underset{(-0.97)}{0.173D(MVT_2)}$$

$$- \underset{(-0.68)}{0.464\,(1 - N_2\hat{\beta}_2)} - \underset{(-1.64)}{0.255R_{WEST}} \qquad R^2 = .12 \quad \text{sample size = 171}$$

The husband's and wife's off-farm participation equations contained the following variables: ED_1, ED_2, AG_1, AG_2, $D(FRAISED_1)$, $D(FRAISED_2)$, R_{WEST}, $\ln V_F$, $(\ln V_F)^2$, $\ln V_o$, $(\ln V_o)^2$, $D(H_1)$, $D(H_2)$, $D(FVT_1)$, $D(HVT_2)$, MSMSA, MCITY, $D(DGD_{1-5})$, AARF. The off farm participation estimate is then included as an explanatory variable in the respective wage equations $(1 - N_i\hat{\beta}_i)$ to treat for sample selection. Given the estimation of the wage equations the imputed wages are estimates of the wage-offer for off-farm labor and are hereafter treated as exogenous variables.

Table 1. A Summary of Empirical Definitions of Variables

Symbol	Definition
T_{iH}	Household labor--work around the house, including food preparation, care of children, cleaning house, shopping, house maintenance, yard and garden work, in annual hours.
T_{iW}	Off-farm labor--work off the farm for a wage or salary, in annual hours. It excludes work at a nonfarm self-employed business and custom or contract work on another farm.
T_{iF}	Farm-labor--work on the farm including chores, caring for livestock, repairing buildings and equipment, keeping records, field work, buying and selling, and custom and contract work performed for other farmers.
T_{iL}	Leisure--the residual of 6205 hours less the reported hours of farm labor, household labor, and off-farm labor, in annual hours.
X_H	Household capital services--the annual rental value on 20 primary (nonrecreational) household appliances and housing, in dollars per year.
W_i	Off-farm wage--annual wage and salary income from off-farm work divided by annual hours of off-farm work, dollars per hour.
ED_i	Education--years of formal schooling completed. It includes elementary, intermediate, high school, and college years but does not include vocational training obtained in a business or trade school.
$D(MVT_i)$	Market oriented vocational training--a 1 - 0 dummy variable, taking the value of 1 if an individual obtained market oriented vocational training in high school or later, and 0 otherwise.
$D(FVT_i)$	Farm oriented vocational training--a 1 - 0 dummy variable, taking the value of 1 if an individual obtained farm oriented vocational training in high school or college (i.e., high school vocational agriculture or college degree in an agricultural curriculum), and zero otherwise.
$D(HVT_i)$	Home oriented vocational training--a 1 - 0 dummy variable, taking the value of 1 if an individual obtained home oriented vocational training in high school or college (i.e., home economics in high school or college degrees in home economics), and a 0 otherwise.
AG_i	Age--individual's reported age in years.
$FRAISED_i$	Raised on a farm--a 1 - 0 dummy variable, taking the value of 1 if individual was raised on a farm, and 0 otherwise.
EX_i	Experience--post-schooling experience defined as age-education-6, in years. This is approximately a measure of work experience at all types of work, not just wage or farm work experience.
$D(H_i)$	Health status-a health status rating reported by the wife for the individual. It takes a value of 1, if a poor health status was reported by the wife for the individual, and 0 otherwise.
K j = 1, 2, 3	Children--the age specific number of children in the household. The age groups are $\leq$ 5 years, 5-11 years, and 12-18.
V_F	Permanent farm income--an estimate of the permanent cash rental on the household's equity in farmland.
V_O	Permanent other income--an estimate of the flow of income from the net value of nonfarm assets of the household (stocks, bonds, a nonfarm business). It does not include transfer or welfare payments.
ACRES	Operated acres--the number of acres owned and operated plus acres rented in and operated. This is one measure of farm size.
D(DAIRY)	Dairy activity--a 1 - 0 dummy variable, taking the value of 1 if the farm reports a dairy livestock activity, and 0 otherwise.
MSMSA	Miles to SMSA--the distance in miles from the farmstead to the nearest Standard Metropolitan Statistical Area.
MCITY	Miles to city--the distance in miles from the farmstead to the nearest city with a population of 10,000 or more.
R_j	Geographical regions--dummy variables, taking value of 1 if household is located in geographical region j and 0 otherwise.
RENT	House rental--the household's estimate of the monthly rental for their house.

Table 1 continued

HAGE	Age of house--the age of the farm house, in years.
ROOMS	Rooms in house--total number of rooms in the farm household, excluding bathrooms, hallways and enclosed porches.
D_1 - D_4	Other housing characteristics--a dummy variable taking the value of 1 if the house has automatic central heat, central air conditioning, attached garage, or is a mobile home, respectively, and 0 otherwise.
$D(DGD_j)$ $j=1,2,3,4,5$	Degree growing days--a set of 1 - 0 dummy variables for degree growing days of < 2800, 2800-2899, 2900 - 2999, 3000 - 3099, 3100 - 3199, and $\geq$ 3200, respectively.
AARF	Average annual rainfall--average annual rainfall in inches for the weather bureau district in which the farm was located.

Table 2. Summary Statistics of Variables

Variables	Mean	Standard deviation
Wife's time:		
Household labor	2,298.0	1,266.0
Off-farm labor	262.6	585.5
Farm labor	416.1	629.8
Leisure	3,228.3	
Husband's time:		
Household labor	243.2	327.7
Off-farm labor	285.3	666.9
Farm labor	2,601.6	1,233.2
Leisure	3,074.9	
Household capital services	2,720.0	
Participation in off farm wage work		
(predicted: Husband	0.25 (0.39)	
Wife	0.28 (0.37)	
Off-farm wage offer (ln) predicted; Husband	1.47	
Wife	1.28	
Education: Husband	11.3	2.2
Wife	12.7	1.7
Market oriented voc. training: Husband	0.73	
Wife	0.89	
Farm oriented voc. training: Husband	0.29	
Home oriented voc. training: Wife	0.72	
Age: Husband	47.8	13.3
Wife	45.3	12.8
Raised on farm: Husband	0.93	
Wife	0.71	
Experience: Husband	30.5	
Wife	26.6	
Poor health status: Husband	0.01	
Wife	0.02	
Children 0-4	0.22	0.51
Children 5-11	0.36	0.54
Children 12-18	0.67	0.89
Household permanent farm income	10,923.3	13,573.7
Household permanent other income	690.1	2,936.6
Acres operated	332.5	256.3
Dairy activity	0.19	
Miles to nearest SMSA	45.1	22.2
Miles to nearest city, pop 10,000	27.9	14.5
Monthly house rental, predicted (142.65)	144.26	30.3
House age	57.7	
Rooms in house	7.1	1.7

Table 3. Instrumental Variable and First Stage Estimates

	ACRES	D(DAIRY)	X_H	T_{2H}	T_{2L}
Constant	-405.63	0.757	-5163.76	2365.66	2217.95
AG_1	12.11 (1.92)	-0.005 (-3.16)			
ED_1		-0.033 (-2.93)			
$D(H_1)$					-128.7 (-0.40)
AG_2		-0.009 (-0.92)	101.30 (1.53)	1.96 (0.45)	11.46 (2.69)
ED_2			-246.64 (-0.72)	-13.26 (-0.59)	24.98 (1.13)
MSMSA			4.19 (-0.17)		
MCITY	3.02 (1.24)			-1.49 (-0.59)	
$(MCITY)^2$	-0.049 (-1.33)				
$D(H_2)$			-1095.97 (-0.23)	-1.90 (-0.01)	432.18 (1.42)
AG_1^2	-0.139 (-1.97)				
V_O			-210.51 (-1.24)	5.61 (0.50)	13.37 (1.22)
V_F			86.85 (0.57)	6.53 (0.65)	10.54 (1.07)
$\ln W_1$	111.98 (1.79)	0.212 (2.01)	-356.78 (-0.13)	80.25 (0.44)	-230.43 (-1.29)
$\ln W_2$	-0.657 (-0.35)	-0.002 (-0.74)	2192.43 (18.79)	-18.12 (-2.36)	19.04 (2.54)
$D(FRAISED_1)$	+92.63 (2.49)				
$D(FVT_1)$	19.11 (0.86)	0.057 (1.45)			
$D(HVT_2)$			543.54 (0.40)	-70.00 (-0.78)	65.92 (0.75)
AARF	7.47 (1.60)	0.009 (1.14)			
$D(DGD_1)$	59.09 (1.88)	-0.209 (-3.77)			
$D(DGD_2)$	42.37 (1.43)	-0.128 (-2.43)			
$D(DGD_3)$	91.46 (3.26)	-0.249 (-5.05)			
$D(DGD_4)$	70.12 (1.93	-0.266 (-4.37)			
$D(DGD_5)$	92.88 (2.10)	-0.217 (-2.86)			
K_1			1168.08 (1.05)	511.24 (7.02)	-273.97 (-3.85
K_2			2118.09 (2.97)	156.40 (3.32)	-79.20 (-1.73)
K_3			3819.26 (6.85)	26.74 (0.73)	-16.8 (-0.47)
	R^2 = .08	R^2 = .11	R^2 = .37	R^2 = .11	R^2 = .12

* t-ratios are in parentheses.

Table 4. Second Stage Estimates

	X_H	T_{2H}	T_{2L}
CONSTANT	3808.72	2473.63	2775.80
$D(H_1)$			-152.48
AG_2	204.66	-.072	8.45
ED_2	-222.17	-18.37	17.09
MSMSA	.178		
MCITY		-1.58	
$D(H_2)$	1840.94	16.86	412.65
V_O	-44.62	6.88	13.33
V_F	240.60	7.91	11.21
$\ln W_1$	-1050.09	-62.04	-28.85
$\ln W_2$	2112.59*	-18.29*	17.53*
$D(HVT_2)$	177.04	-95.42	58.23
K_1	5326.99	512.49*	-276.81*
K_2	3447.13	162.49*	-71.17
K_3	4018.77*	29.20	-8.31
ACRES		0.849	-0.922
D(DAIRY)		-352.24	-531.51
X_H		-1.92	2.82
T_{2H}	-11.88		
T_{2L}	-7.01		
R^2	.37	.12	.12

* notes coefficients where $\beta/SE_{(\beta)}$ exceeds 2.

Table 5. Household Capital-Labor Ratio *

	X_H/T_{2H}
Constant	0.354
AG_2	0.026 (1.17)
ED_2	-0.008 (-0.08)
MSMSA	-0.002 (-0.29)
MCITY	0.015 (1.22)
$D(H_2)$	-0.50 (-0.34)
V_O	-0.085 (-1.66)
V_F	0.037 (0.80)
$\ln W_1$	0.415 (0.44)
$\ln W_2$	-0.005 (-0.15)
ACRES	-0.003 (-0.93)
D(DAIRY)	-0.13 (-0.09)
K_1	0.208 (0.69)
K_2	0.56 (2.62)
K_3	1.23 (7.31)
$D(HVT_2)$	.266 (0.64)
	$R^2 = .10$

* t-ratios are in parentheses.

III. The Results

In this section, we present an estimate of our econometric model. These results include (a) least-squares estimates of the probability of dairy livestock farming and least-squares estimates of the operated acres of the farm (b) two-stage least squares estimates of the demands for household capital services, wife's household labor, and wife's leisure. The previously noted predicted off-farm wage offer, corrected for sample selection, replaces the actual off-farm wage offer for all individuals irrespective of their off-farm work decision.

Because a livestock activity may be a substitute for off-farm wage work, we let the presence of a dairy livestock activity be endogenous and replace the dummy variable D(DAIRY) with its predicted probability. We assume that husband's and wife's training and numbers of children are exogenous. We argue that adjustment costs for age-specific number of children are large, especially relative to the adjustment cost for household appliances and housing. Thus, it may be reasonable to treat age-specific numbers of children as exogenous. Furthermore, one cannot explore the effect of age-specific numbers of children on the labor intensity of household production if they are excluded from the analysis. Operated acres is also treated here as an endogeous variable and we replace the observed operated acres with the predicted ACRES. The instrumental variable estimates of D(DAIRY) and ACRES are shown in Table 3. Also included in Table 3 are the first stage estimates of household capital services, wife's household labor, and wife's leisure.

The instrumental estimate of ACRES shows significant differences occuring in the operated acres due to differences in degree growing days. If the husband was raised on the farm the operated farm size is significantly larger. Average farm operated acres are 332.5 and the coefficient of D($FRAISED_1$) is significant and relatively large to the mean. The significance of the coefficients of the set of degree growing days also indicates significant differences in the probability of dairy livestock operation associated with climatic conditions. The coefficients associated with husband's age and education are negative and statistically significant at the -05 level in the D(DAIRY) estimate.

The first-stage estimates of the household's demands for household capital services, wife's household labor, and the wife's leisure are dominated by the consistent statistical significance of the estimated $\log_e$ of the wife's off-farm wage offer and the age-specific numbers of children. In general, the results reported in Table 3 indicate the relative time-intensive nature of the presence of very young children in the home and the relative capital service-intensive nature of older children. It should be noted that the construction of the off-farm wage offer estimates, with the sample selection correction term, no doubt captures much of any education and training effects as well as some income effects.

The two-stage least-squares estimates of X_H, T_{2H}, and T_{2L} are shown in Table 4. Unfortunately, the use of two stage least squares precludes fitting the household capital-labor ratio to the same set of explanatory variables as the estimates of X_H and T_{2H} at the second stage. However, using the predetermined variables employed at the first-stage allows a limited comparison of relative and absolute factor intensities of household production. The estimated capital-labor ratio of household production is shown in Table 5.

The results shown in Table 4 indicate, as initially hypothesized, the importance of the distinction between leisure and household labor. The demand for wife's leisure behaves quite differently from the demand for her household labor. These equations are again dominated by the importance of the estimate of the wife's off-farm wage offer and the age-specific number of children.

In the demand equation for the wife's household labor the estimated coefficients of wife's education and possession of any home-oriented vocational training are both negative, this suggests reductions in household labor for women with training in these areas. However, both coefficients have $\beta/SE_{(\beta)}$ ratios less than two. Any release of labor due to enhanced efficiency must be used up in increased demand for household labor due to the rise in real income. Thus, all effects of wife's training and education seem to be coming through her off-farm wage offer. As we hypothesized in the theoretical model, the youngest children cause the largest increase in wife's household labor.

In the demand equation for household capital services, the estimates of the two permanent income coefficients are of opposite sign, but both have $\beta/SE_{(\beta)}$ ratios less than two. Although our model was ambiguous on the prediction, household capital services and wife's time are gross substitutes (pure substitutes, if the income effect is really zero). The estimated coefficient of wife's wage offer is positive and has a large β/SE ratio. On the other hand, husband's time and household capital services seem to be complements. The estimated coefficient for the eldest age-specific number of children has a $\beta/SE_{(\beta)}$ ratio in excess of two and would seem to carry two impacts. First, a difference in factor intensity of household production by ages of children, and secondly no doubt some household life-cycle impact of accumulation of household capital.

The estimated coefficients of wife's wage offer and the youngest age-specific number of children have opposite signs in the demand for wife's leisure from what is estimated in the demand for wife's household labor. In these cases the $\beta/SE_{(\beta)}$ ratio exceeds two. Again, education and training effects seem to be coming through the off-farm wage offer. Both wife's education and possession of home-oriented vocational training have positive estimated coefficients but these have $\beta/SE(\beta)$ ratios less than two. Both instrumental farm measures, D(DAIRY) and ACRES have negative estimated coefficients, however, their $\beta/SE(\beta)$ ratios are less than two.

While none of the included endogenous variables at the second-stage have $\beta/SE(\beta)$ ratios exceeding two the signs of the estimated coefficients are consistent with the results noted earlier indicating the gross substitute nature between household capital services and wife's household labor. The estimated coefficient of wife's labor is negative in the household capital service equation, and the estimated coefficient of household capital services is negative in wife's household labor equation.

As noted previously, the use of two-stage least-squares precludes the estimation of a capital-labor ratio in household production employing an identical set of explanatory variables as the 2SLS equation. However, a household capital-labor ratio was regressed on the set of predetermined variables from the first stage. The results reported in Table 5 are quite consistent with expected results (in terms of anticipated signs) from examining estimated coefficient signs from the 2SLS equations for household capital services and wife's household labor. The estimated coefficients of wife's age and possession of home-oriented vocation training are positive, although the t-ratios are small. The significance of the estimated coefficients of age-specific numbers of children indicate the relative strong role of family size and composition on relative factor intensities of household production, with older children being relatively more capital intensive.

IV Comparisons

This study has presented econometric estimates of equations explaining absolute and relative factor intensities in farm household production. The study by Bryant (1976), although not completely comparable to ours, provides the main alternative study of household capital labor ratios. Bryant finds that unearned income generally has a positive effect (marginal statistical significance) on the capital-labor ratio. Our analysis shows that permanent farm income has a positive but not statistically significant effect on both capital services and the capital-labor ratio. The coefficient of permanent other income is negative but also not significantly different from zero in the capital service or capital-labor ratio equations.

Bryant found that the number of household members had a positive and statistically significant effect on the capital-labor ratios of several of his household subgroups. We divided children into three different age groups. The numbers of children in the two older age groups have positive and significant effects on the household capital-labor ratio. Furthermore, the size of this coefficient doubles in going from one age group to another. Thus, the substitutibility of household capital services for wife's household labor increases as children become older.

Bryant's measure of wife's hometime includes her leisure, personal care time, and household labor. Our results show that wife's household labor and leisure behave quite differently with respect to the explanatory variables. Thus, we cannot over emphasize the importance of treating leisure and household labor separately in studies of household production.

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Appendix A. Durable household goods included in appliance component of capital services.

Durable goods	Average age	Estimated life-span	Prices of new goods, adjusted to 1972 = 100
1. Automatic clothes washer	6	11	220
2. Wringer washer	10	20	150
3. Automatic dryer	7	13	210
4. Refrigerator	8	15	300
5. Stove	7	13	280
6. Freezer	8	20	190
7. Dishwasher	5	11	250
8. Microwave oven	3	13	450
9. Sewing machine	7	13	120
10. Lawn mower	6	15	80
11a. Garden tractor or tiller < 3.5 H.P.	7	15	190
11b. Garden tractor or tiller $\geq$ 3.5 H.P.	7	15	250
12. Electric fry pan	5	10	23.50
13. Electric mixer	5	10	20
14. Electric blender	5	10	23.50
15. Toaster	4	10	14.00
16. Electric can opener	5	10	13.50
17. Slow cocker (crockpot)	3	10	20
18. Electric iron	5	10	18
19. Electric hair dryer	4	10	17
20. Vacuum cleaner	6	12	145