# OFF-FARM LABOR SUPPLY AND THE VALUE OF THE FARM OPERATOR'S TIME

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The purpose of this paper is to derive a common set of parameters which underlie the functions determining the probability that a farm operator works off the farm (at the zero off-farm work days position), his days of work, off-farm daily wage, and his asking wage. Two functions are derived. The first describes the behavior of the off-farm daily wage faced by the operator. The second function determines the value of the asking wage, which is the value the farm operator places on his time. The two wage rates are assumed to be equal if the farm operator works in the nonfarm sector. It is further assumed that no off-farm offered wage matches the farmer's value of time (asking wage) if the farmer does not spend any days off the farm in alternative employment activities. This derivation is a take-off from some of the recent work concerning off-farm work by Polzin and MacDonald [12], Gardner [5], Hanson [8], and Huffman [9].

The model is applied to the off-farm work situation in West Central and Southwestern Ohio within and contingent to the Dayton and Cincinnati SMSA's. A survey of farm operators and household members was taken in these areas during the summer of 1974 as part of a larger study of farm labor markets and their relation to labor markets in the nonfarm sector.

## Some Theoretical Considerations

The theory of the supply of working time of individual members of a household emerges from the theory of household behavior suggested by Becker [4] and Mincer [10], and is contained in the work by Huffman [9],

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Aigner [1], and Gronau [7]. Only a brief sketch of the theory is given here in order to introduce the approach used to determine the influence of economic forces on the off-farm labor supply of farm operators and their asking wage.

The household is assumed to maximize a well-behaved, twice differentiable utility function subject to time, wealth, and other constraints expressed as,

(1) $$U(X_i)$$

The $X_i$ are the $i = 1, \ldots n$ commodities including categories of leisure. Let $X_n$ be the farm operator's off-farm leisure. Let $Y_o$ be asset income, $P_i$ be the price of the ith commodity, and T be the amount of time available to the farmer. ~~$d = T - X_n$~~ $d = T - X_n - X_{n-1} - f$ is the days of work in off-farm employment activities and is associated with wage $P_n$.

$X_{n-1}$ = farm leisure
$f$ = days of farm work

The household is assumed to maximize (1) for fixed d subject to:

(2) ~~$$\sum_{i=1}^{n-1} P_i X_i - Y_o - P_n d = 0$$~~

(2) $$\sum_{i=1}^{n-2} P_i X_i - Y_o - P_n d - P_{n-1} f = 0$$

and,

(3) ~~$$T - X_n - d = 0.$$~~

(3) $$T - X_n - X_{n-1} - d - f = 0$$

The LaGrangian may be written as

(4) $$U(X_i) - \lambda(\sum_{i=1}^{n-1} P_i X_i - Y_o - P_n d) - \delta(X_n + d - T),$$

where $\lambda$ and $\delta$ are multipliers.

The first order conditions become,

$$U_i - \lambda P_i = 0$$

(5) ~~$U_1 - \delta = 0$~~ $$U_n - \delta = 0$$

(6) ~~$U_2 - \lambda P_1 = 0$~~ $$U_{n-1} - \delta = 0$$

$$i = 1, \ldots, n - 1$$

and (2) and (3) above. Constraint (3) will always hold given that the marginal utility of leisure is positive. A system of equations for $X_1$, ... $X_{n-1}$, $\lambda$, $\delta$ may be solved as functions of $P_1$, ..., $P_{n-1}$, and $P_n d + Y_o$.

The shadow price of time may be defined as

$$U_1/\lambda = \delta/\lambda, \tag{7}$$

which defines the value the household places on marginal units of the farm operator's time, particularly in off-farm employment.[1] The utility function is defined for quantities of leisure in excess of the amount T currently available. The houshold may decide to augment the operator's time by acquiring perfect substitutes for his or her production time in farm employment or home production activities, and this time can be defined as negative work. This condition will be met if the household can imagine having more of the operator's time available than currently exists.[2]

Relation (7) may be written as,

$$U_1/\lambda = W', \tag{8}$$

for any arbitrary $P_n$, and where,

$$W' = f(d, P_n d + Y_o, P_1, \ldots P_{n-1}). \tag{9}$$

Equation (9) is defined whether or not labor supply functions exist. In order for a particular combination of d, $P_1$, ... $P_{n-1}$, $Y_o$ to be an equilibrium solution to the utility maximization problem described above, with d voluntarily chosen, it is necessary that $W' = P_n$. The income from the wage $P_n$ must yield a value of the shadow price which is equal to the wage. The relationship between W' and d defines the labor supply function of farm operator's to off-farm employment activities. Assuming continuity of the function in (9) above implies continuity in the labor supply function, i.e., over the domain of d where equilibrium values exist. Given the above assumptions about preferences, the value W' can always be adjoined at d = 0, and continuity of the function assures that "adjoined" labor supply is continuous in equilibrium wages.

Assuming that sufficient conditions for a labor supply function exist, an "adjoined" labor supply function also exists. Those conditions are not given or proven here, but the essence of the proof is to show that the marginal rate of substitution between commodities and leisure increases at a decreasing rate for increasing utility levels. Assuming that the labor supply function for off-farm work by farm operators is a monotonic (and positive) relationship, the "adjoined" labor supply function can be solved for equilibrium values of W' and takes the form,

(10) $$W' = g(d, \underline{P}, Y_o).$$

$\underline{P}$ is a vector of commodity prices. All commodities including other leisure can be grouped into a composite commodity associated with composite price P.

There may be other conceivable constraints introduced into the household utility maximization problem developed above which influence the supply of days offered to the nonfarm sector by farm operators. Such things as age, education, distance from jobs, etc., may be candidates. The relation (10) then would take the expanded form,

(11) $$W' = g(d, \underline{P}, Y_o, \underline{Z}),$$

where $\underline{Z}$ is a vector of constraints.

What has been developed is a shadow price (asking wage) function relating the asking wage to days of off-farm work, remaining prices and wages, other income, and other constraints imposed by the consumption technology and previous economic choices. The usual convention is to derive the commodity and leisure demand relationships as functions of prices and wages, asset income, and other constraints. Assuming interior solutions, it has been possible to express the asking wage function as above. A necessary equilibrium condition for positive quantities of commodities to be purchased is that their prices be equated with their marginal values, while no quantities are purchased if the prices exceed the marginal valuation at zero quantities of goods. For the case of leisure (or labor supply), similar conditions exist, except that two possible solutions exist: i.e., a person may not work less than zero days in any one employment activity and, given a fixed amount of time in any period, a person cannot work more than that amount of time. Equilibrium at the first corner exists if the marginal value of leisure at the maximum quantity exceeds the market wage. Equilibrium at the second corner exists if the marginal value of leisure at zero quantities is less than the market wage. The market wage is the offered wage in the nonfarm sector to farm operators in the context of the present formulation. The asking wage function developed enables a characterization of both interior and corner solutions using a common framework, i.e., the shadow price relation is defined at the corner where the demand functions are not defined.

The offered wage (market wage of farm operators in nonfarm employment activities) is a function of the interaction of the supply of operators to off-farm employment activities and the demand for such workers in those activities. Lacking information on the demand side, particularly its structure, and no readily available data to estimate the demand and supply structure, some notions with respect to the determinants of market wage behavior following the work of Gisser [6] and Perkins and Hathaway [11] are used, and an offered wage function is specified as,

$$W = h(E, L). \qquad (12)$$

W is the offered wage (market wage), E is the education of the farm operator, and L is the off-farm labor market experience of the farm operator. Previous research suggests that the offered wage ought to be positively related to both education level and tenure of employment in the nonfarm sector.

The above two wage functions define the model of the off-farm labor supply decision of the farm operator. If the operator is free to adjust his days of work, then the equilibrium condition will be,

(13) $$W' = W$$

If no work is offered to off-farm employment activities, and since days of work in the off-farm activities cannot be negative, then,

(14) $$W' \geq W$$

must hold. Days of work in off-farm employment adjust in the model to equate the offered with the asking wage. A necessary condition for equilibrium to occur is that the offered wage exceed the asking wage at zero days of off-farm work.

## Empirical Specification and Estimation

The empirical specifications of the two wage functions are given as,

(15) $$W_i' = a_0 + b_1 d_i + b_2 Y_{o_i} + b_3 Y_{f_i} + b_4 E_i + b_5 C + b_6 M + b_7 W_{s_i} + \varepsilon_i'$$

and

(16) $$W = b_0 + b_1 E_i + b_2 L_i + \varepsilon_i$$

where $W'$, $W$, $d$, $Y_o$, $E$, and $L$ are as defined previously, and $a_i$, $b_i$ are parameters with $i = 1, \ldots, n$ operators. $\varepsilon'$ and $\varepsilon$ are the disturbance terms of the empirical equations.[3] $Y_f$ is the net farm income of farm households. C is the number of children under 6 years of age in each household; M is the distance to off-farm employment; and $W_s$ is the wage of the spouse (in all cases, the nonfarm wage of the wife). These additional variables are the expanded set of prices, wages, and constraints on the household utility maximization decision. The prices of consumption commodities are dropped in the cross-section analysis assuming prices paid by all households are the same.

It is assumed that the disturbances are uncorrelated with the regressors, but observed days of off-farm work by farm operators depends on the disturbances. If an operator is at the corner, i.e., zero days of off-farm work, then the condition $W' < W$ holds if,

$$\begin{aligned}(17)\quad & b_0 - a_0 + b_1E_i + b_2L_i - a_2Y_{o_i} - a_3Y_{f_i} - a_4E_i - a_5C_i \\ & - a_6M_i - a_7W_{s_i} > \varepsilon_i' - \varepsilon_i,\end{aligned}$$

and days of off-farm work adjust such that $W' = W$. The adjustment depends on the magnitude of the difference $\varepsilon_i' - \varepsilon_i$. Inequality (17) is the same as derived and estimated in the work of Gronau [ 7 ].

An off-farm market wage, $W_i$, and days worked $d_i$, will be observed if, and only if, (17) holds. Observed off-farm market wage and days worked become functions.

$$(18)\quad W_i = b_0 + b_1E_i + b_2L_i + \varepsilon$$

$$\begin{aligned}(19)\quad d_i = & \frac{1}{a_1}(b_0 - a_0 + b_1E_i + b_2L_i - a_2Y_{o_i} - a_3Y_{f_i} - a_4E_i \\ & - a_5C_i - a_6M_i - a_7W_{s_i}) + \frac{\varepsilon_i - \varepsilon_i'}{a_1} .\end{aligned}$$

Equations (18) and (19) can be estimated using observations on d and W only if condition (17) holds, and hence the disturbances of (18) and (19) are conditional on (17) and have conditional distributions. The same variables (exogenous) that appear in (18) and (19) also appear in condition (17). Thus, the characteristics of the distributions of the disturbance terms of (18) and (19) depend on the values of the exogenous variables for each observation. It is therefore not possible to obtain unbiased or consistent estimates of (18) and (19) using OLS or an instrumental variables estimation technique.[4]

Consistent parameter estimates can be obtained using the known relationship between conditional and unconditional distributions and Amemiya's [2, 3] proof of the consistency and asymptotic normality of the estimator when the dependent variable is truncated normal. Given a sample of n farm operators containing j who are observed to offer some work off the farm and n-j who do not, the likelihood function for the n observations is expressed as,

$$G = \prod_{i=1}^{j} Q(d_i, W_i | W_i > W'_{i\,d=0}) \cdot \Pr(W_i > W'_{i\,d=0}) \tag{20}$$
$$\prod_{i=g+1}^{n} \Pr(W'_i > W_{i\,d=0}) \quad .$$

$Q(\cdot)$ is the joint distribution of observed days of off-farm work and wages for the ith operator who works off the farm and $\Pr(W_i > W'_{i\,d=0})$ is the probability that the operator will work off the farm at zero quantities of time offered to off-farm employment, i.e., at d=0, when offered wage exceeds asking wage. Maximization of (20) with respect to the parameters of the model, equations (15) and (16), including the variances and covariances of the respective disturbances, yields consistent and asymptotically efficient parameter estimates which are asymptotically normally distributed.

Preliminary limited information, maximum likelihood estimates of the parameters of the offered and asking wage functions are presented in Table 1 along with the associated asymptotic standard errors. All wages are in terms of daily wages, while net farm income is gross farm receipts and

Gronau[7] estimated The inequality (17) by probit analysis — I have since been told and have read a 1974 Econometrica article by J. Heckman with similar estimation problems and approach —

Table 1. Estimates of the Offered-Asking Wage Model for Off-Farm Work by Farm Operators in Ohio, 1974.[a,b]

| Variable | Equation | |
|---|---|---|
| | Offered Wage | Asking Wage |
| Constant term | -3.491<br>(1.069) | -87.879<br>(22.653) |
| Days of off-farm work | | 0.812<br>(0.293) |
| Wage of spouse | | 0.298<br>(0.094) |
| Distance to off-farm job | | 0.254<br>(0.088) |
| Education of farm operator | 0.748<br>(0.296) | 0.462<br>(0.116) |
| Off-farm work experience | 0.321<br>(0.107) | |
| Net farm income | | 0.007<br>(0.002) |
| Other income | | 0.006<br>(0.005) |
| Children under 6 years | | 0.732<br>(0.271) |

[a]Offered and asking wage are in logarithms.

[b]Asymptotic standard errors in parentheses

government payments minus production expenses. Other income includes income from nonfarm assets in those cases where such information could be obtained. Education of the farm operator is measured as the number of years of formal schooling, while off-farm work experience is measured as the number of months in off-farm work experience above three months. Distance is measured as the number of miles, one way, from place of residence to off-farm job location.

All estimated coefficients are at least twice the size of their asymptotic standard errors, with the exception of the coefficient for other income. A 10 percent increase in the number of years of formal schooling increases the logarithm of the offered wage by roughly 7.5 percent, while a 10 percent increase in off-farm work experience increases the offered wage by roughly 3 percent. Schooling has a slightly greater effect on the offered wage than it does on the asking wage of the farm operators sampled. The presence of preschool children in the household is seen to have a positive effect on the asking wage of the farm operator. This is a result similar to that found by Huffman [9] in his earlier work.

The estimated coefficients can be used to generate the probability that a farm operator works off the farm, i.e., $Pr(W_i > W'_{i_{d=0}})$, and the actual days worked off the farm by an operator using equation (19) above. Table 2 presents the probabilities that a farm operator will work off the farm for various levels of net farm income and years of formal schooling given that all other variables are held at their means. The probability, $Pr(W_i > W'_{i_{d=0}})$, is expressed, in the present specification, by $Pr(b_0 - a_0 + b_1E_i + b_2L_i - a_2Y_{0i} - a_3Y_{f_i} - a_4E_i - a_5C_i - a_6M_i - a_7W_{s_i} > \varepsilon_i - \varepsilon'_i)$ and is generated by $Pr(Cb_0 - a_0 + b_1E_i + b_2L_i - a_2Y_{0i} - a_3Y_{f_i} - a_4E_i - a_5C_i - a_6M_i - a_7W_{s_i})/(\sigma^2_\varepsilon + \sigma^2_{\varepsilon'} - 2\rho\sigma_\varepsilon\sigma_{\varepsilon'})^{\frac{1}{2}} > (\varepsilon_i - \varepsilon'_i)/(\sigma^2_\varepsilon + \sigma^2_{\varepsilon'} - 2\rho\sigma_\varepsilon\sigma_{\varepsilon'})^{\frac{1}{2}})$.

Table 2. Estimated Probabilities of Off-Farm Work by Farm Operators in Ohio, 1974.

| Net Farm Income | Years of Schooling | | | | |
|---|---|---|---|---|---|
| | 8 | 10 | 12 | 14 | 16 |
| $2000 | .571 | .573 | .574 | .575 | .577 |
| $3000 | .565 | .566 | .567 | .569 | .569 |
| $4000 | .558 | .560 | .561 | .562 | .564 |
| $5000 | .552 | .553 | .554 | .556 | .557 |
| $6000 | .545 | .547 | .548 | .549 | .551 |

As shown in Table 2, the probability that the farm operators will take off-farm work is above 50 percent and ranges from approximately 55-58 percent depending on years of schooling and net farm income, given that other income, education, number of preschool children, distance, and the wage of the spouse are held at their mean values. Other probabilities can be generated using combinations of the other variables which influence the value of the operator's time.

In conclusion, an approach has been used which estimates the influence that economic variables have on both the offered wage and the asking wage of farm operators, and which generates the probability of off-farm labor supply offer by operators as well as the off-farm labor supply function. It was found that education of the farm operator, the wage of the spouse, location with respect to off-farm jobs, net farm income, and the number of preschool children in the farm household all have an effect on the value of the farm operator's time, the probability of working off the farm, and the supply of labor offered to off-farm employment activities. Using equations (18) and (19), the off-farm wage (offered wage) and off-farm supply relations, and the estimated coefficient for off-farm work days from Table 1, the estimates suggest that a 10 percent increase in off-farm wage (in logarithmic units) induces roughly a 12 percent increase in days of off-farm work.

## FOOTNOTES

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1. The argument presented on page 3 holds if there are many separate uses for the farm operator's leisure as derived by Becker [4]. The other main use of the farm operator's leisure is that of work on the farm.

2. This is the same as the household being able to evaluate baskets of market commodities not currently attainable given its current budget constraint. This assumption is not equivalent to the assumption that the preference map is defined for negative quantities of commodities or time since days of work in the present context indicate the absence of time to be used for leisure from farm or home production activities. The days of work do not enter as a direct argument in the utility function.

3. The disturbances reflect variations known to the households or operators as a result of their individual decisions.

4. The instruments would have come from condition (17).

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