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The Supply of Off-Farm Labor: A Random Coefficients Approach

1990

by

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off-farm employment

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Introduction

Nonfarm sources of employment for farm families has become an increasingly important source of income to farm families. Fewer than 30% of farm operators reported working off-farm in 1944 whereas 53% reported working off-farm in 1982 (Ahearn and Lee). In 1987, more than 48% of farm operators reported some off-farm employment and more than 50% of these operators worked off-farm more than 250 days (Oliveira). Off-farm employment is not only prevalent, but appears to be a permanent part of farm structure as well. Many farm families are increasingly reliant on nonfarm sectors of the economy and are just as sensitive to general economic conditions as they are to conditions within the farm economy.

There has been substantial theoretical and empirical work on off-farm labor supply decisions by farm families (Huffman; Sumner; Simpson and Kapitany). Theoretical models have focused on time allocation by the family (i.e., Huffman; Gronau) and empirical models have typically focused on a single family member (Jensen and Salant; Furtan, et al.; Rosenfeld). Recently, empirical models have been extended to joint estimation of operator/spouse or male/female decisions (Huffman and Lange; Gould and Saupe). All of the empirical models have used fixed coefficient methods estimation. One of the important theoretical results from utility models of the allocation of time is that expected signs for parameters of empirical models are ambiguous. For example, the sign for the elasticity of

off-farm supply with respect to the off-farm wage may be negative or positive. The objectives of this paper are to investigate the usefulness of random coefficients models (RCM) for estimating off-farm supply functions and investigating the variation in estimated parameters. Application of the RCM to off-farm supply decisions of farm operators and spouses will allow the estimation of a parameter vector for each individual. Comparison with fixed parameter estimates will then provide some indication of the validity of constant parameter results.

Model Specification

Farm households are assumed to maximize utility (Huffman):

$$(1) \qquad U = U(Y, L_1, L_2; H_1, H_2, E).$$

subject to the constraints:

$$(2) \qquad P_y Y = P_q Q - RX + w_1 M_1 + w_2 M_2 + V;$$

$$(3) \qquad Q = f(X, F_1, F_2; H_1, H_2, G);$$

$$(4) \qquad T_i = L_i + F_i + M_i; \quad \text{and} \quad M_i \geq 0, \ \text{for } i = 1,2.$$

We assume, for simplicity, that consideration of leisure for the operator (i=1) and spouse (i=2) is sufficient for the maximization of household utility (Gronau). The household chooses the levels of purchased goods (Y), leisure (L_1 and L_2), farm labor (F_1 and F_2), off-

farm labor (M_1 and M_2), farm inputs (X) and farm output (Q). Given are the stocks of human capital for each individual (H_1, H_2), prices (P_y,P_q,R), off-farm wages (w_1,w_2), other income (V) and other exogenous factors which shift the utility function (E) or production function (G). Both the operator and spouse are assumed to have opportunities to supply on-farm labor (F_1 and F_2) and off-farm labor (M_1 and M_2). The typical budget constraint is imposed on the household with farm profits and off-farm wages contributing to household income. Constraints on the total amount of time available are imposed; leisure, on-farm labor and off-farm labor compete for the allocation of time. The problem is then similar to the analysis of multiple job holdings by Shishko and Rostker. An important difference arises in that the wage received for farm work is not assumed constant. Given the normal regularity conditions for the production function, on-farm labor by both the operator and spouse will face diminishing marginal returns. The production function therefore imposes an additional constraint on the maximization of utility by the farm household. The final constraint, equation (4), includes an inequality constraint on hours of off-farm work.

An interior solution exists for an individual if optimal allocations of time to leisure, on-farm work and off-farm work are all non-zero. The optimal levels of the choice variables can then be determined by solving the set of first order conditions (see Huffman). However, corner solutions may exist for off-farm work by both the operator and spouse. Supply functions for off-farm labor by the operator and spouse are then determined by simultaneous solution of the Kuhn-Tucker conditions. Huffman and Lange have considered the conditional nature of farm family decisions and, in particular, the implications for the off-farm supply functions by the husband and wife. In this paper, we consider individual off-farm labor

supply functions for the farm operator and spouse. We are therefore assuming that off-farm supply decisions are not made jointly by the farm family.[1] The reduced form of the off-farm supply function for individual i is then:

$$(5) \qquad M_i = M_i(w_i, P_y, P_q, R, H_i, E, V, G) .$$

Since decisions are assumed non-joint, the supply function for individual i does not depend upon individual j's wage.

We assume that the parameters of the supply functions are stochastic. Dropping the subscript for the operator (i=1) and spouse (i=2) for expository purposes, the empirical model is specified as follows:

$$(6) \qquad M_n = Z_n'\beta_n , \qquad for \quad n = 1,2,\ldots,N.$$

where Z_n is a (K $\times$ 1) vector of nonstochastic exogenous variables affecting the n^{th} individual's off-farm labor supply (M_n). The (K $\times$ 1) random coefficient vector (β_n) is assumed to have the following specification:

$$(7) \qquad \beta_n = \overline{\beta} + v_n .$$

where $\overline{\beta}$ is a (K $\times$ 1) vector of nonrandom mean coefficients and v_n is a vector of random disturbances. The vector v_n is assumed to be distributed with $E(v_n) = 0$ and covariance matrix $E[v_n v_n'] = V$ with $E[v_n v_m'] = 0$ if $n \neq m$.

The model is a simplified version of the RCM of Swamy and Tinsley. In particular,

there are no time dimensions in the model and the stochastic process generating the parameters is assumed to be stationary. Combining (6) and (7) we can write the supply function:

$$(8) \qquad M_n = Z_n' \bar{\beta} + e_n ;$$

where: $e_n = Z_n' v_n$; $e_n \sim (0, \sigma_n^2)$ *and* $\sigma_n^2 = Z_n' V Z_n$.

The Swamy and Tinsley model provides estimates of the mean parameter vector $\bar{\beta}$ and the elements of V. Individual parameters can then be predicted and the distribution of values considered. Of particular interest are the individual labor supply responses to changes in the off-farm wage rate. These estimates are compared to OLS estimates where the stochastic error is attached to the dependent variable and the conditional nature of the error structure is modeled. The OLS results employed the two-stage Heckman approach to adjust for possible sample selection bias.

Data

Data used in the analysis were obtained from surveys of Massachusetts and Pennsylvania farm households. A sample of farms was randomly drawn from tapes of the Agricultural Stabilization and Conservation Services (ASCS) stratifying by county. The survey was conducted by telephone interview from November 1986 through April 1987. There were 159 completed questionnaires for Massachusetts farm households and 989 for

Pennsylvania, a response rate of about 30 percent.

The ASCS list of farms may not accurately represent the true farm population for the following reasons. First, the proportion of farmers enrolled in national farm programs may be lower than desired. Given crop mix in these states, especially Massachusetts, farmers would not be expected to take advantage of federal farm programs. Secondly, there may be a large percentage of rural families who own several acres of woodland or pasture that has been included in a program designed to preserve open space. The discrepancy between the USDA estimate of the number of farms in Massachusetts (about 6,000) and Pennsylvania (about 58,000) and the ASCS population sizes on the tapes (8,229 for MA and 90,336 for PA) indicated that the latter problem existed. Respondents who were not currently farming were screened early in the interview. The first problem could not be addressed easily.

Theory suggests that prices and other exogenous factors should be arguments of the supply models. However, all households in the sample were assumed to face similar price levels with the exception of wages. The wage rate is assumed to represent market demand for labor and an exogenous evaluation of the individual's stock of human capital. The analysis will focus on impacts of wages and other exogenous factors on off-farm supply decisions. Individual characteristics include measures of human capital stock, age and sex for the operator and spouse. Farm experience, education, off-farm experience and job training are assumed to measure the stock of an individual's human capital. Human capital enhances an individual's productivity on farm, raising the shadow value of farm labor. Human capital may also have direct affects on individual decisions to supply labor to the off-farm markets. The combination of these impacts on the supply of off-farm labor is uncertain.

Previous empirical evidence has generally found positive impacts of education on the supply of off-farm labor. Farm experience has been shown to decrease the hours supplied while off-farm experience has generally had the opposite impact. Age is typically included in quadratic form to capture life-cycle effects. Recent studies have found evidence of a life-cycle effect (Huffman and Lange) while others have found conflicting results (Rosenfeld, Leistritz, et al.). Where the life-cycle effect is observed, hours supplied peak between ages 45 and 55. Sex is included in the model to capture differences between male and female supply.

The number of children in the household has been found to be most important to supply decisions by women (Rosenfeld, Thompson). Since 89 per cent of spouses in the sample for Massachusetts were women, it is expected that a greater number of children in the household will decrease hours supplied by the spouse (virtually all spouses were women in the Pennsylvania sample). Age of the children has also been shown to be important with pre-school children having the greatest impacts. The impacts on decisions by operators is uncertain.

A number of categorical and binary variables are included as characteristics of the farm. Ideally, the quasi-rent or production function would be estimated and predicted values included in the supply models (Huffman, Streeter and Saupe). However, the necessary data were not available from the survey. A categorical variable measuring farm sales was used as an alternative. In addition, binary variables for farm organization and dairy farms were included. Financial characteristics of the farm family are included to capture the effects of exogenous non-wage income. If leisure is a normal good, higher levels of other income would result in fewer hours of off-farm employment. Previous empirical results generally

support this hypothesis although estimates have been inelastic. The final set of variables capture location relative to the job and the vitality of the local labor markets. Commuting distance indicates the fixed costs associated with participation and labor supply. Cogan has shown that the effects of such "time costs" are ambiguous. Unemployment rates for 1985 were collected for the sample by town of residence (Massachusetts Department of Employment and Training). Greater levels of unemployment should result in lower levels of participation and fewer hours supplied due to excess supply in local labor markets.

Results

RCMs were estimated for operators and spouses of both the Massachusetts and Pennsylvania data sets. The random coefficients estimates are summarized in Tables 1 and 2 for farm operators and spouses, respectively. The mean parameter estimates are presented and are compared to ordinary least squares (OLS) estimates which have been corrected for sample selection bias. Comparison of the results of the RCM and the OLS results show that estimates are robust. Few differences were observed between the mean parameter vector for the RCM and the two-stage sample selection results.

Several individual characteristics of the operator and spouse had significant impacts on hours supplied. Experience in off-farm employment was found to be positively related to the number of hours supplied. Negative relationships between age and hours worked were observed for operators and spouses, with the exception of the PA operators. Job related training also had a negative impact on the number of hours worked with one exception.

It is evident from the results that family characteristics are important to the supply

decisions of both the operator and spouse. Farm operators in MA reduced off-farm supply when children under five years of age were present while PA operators increased hours worked. The spouse's time off-farm was generally reduced by pre-school children, but not significantly. School-age children reduced off-farm work by the spouse and increased hours worked by the operator. Operators may be released from farm chores as children become valuable sources of labor. In addition, operators may increase hours worked due to greater financial needs. An additional variable was included to capture the effects of participation by an individual's spouse in the off-farm markets. Previous efforts to model joint decision-making by the operator and spouse suggested decisions are made independently as noted above. An ad hoc specification employing predicted probabilities from probit models as explanatory variables was used here. Only MA farm operators had a significant response to the spouse working off-farm.

Farm characteristics had significant impacts on the operator's supply, but little impact on the supply of the spouse. Thompson suggested that operator decisions are primarily determined by the farm operation while the spouse's decisions depend on family characteristics. These results support her hypothesis for farm spouses; however, the operator was found to respond to both household and farm factors.

It was anticipated that greater sources of other income would decrease the number of hours worked off-farm. The expected result was observed only for PA farm operators. Supply by the spouse was also unresponsive to local economic conditions. Operators in MA worked more hours in response to commuting distance and worked fewer hours when labor markets exhibited relatively greater excess supply. The positive effect of commuting distance

suggests that operators are aware of the time-costs associated with participation. By working more hours, fixed time-costs are partially offset.

The effects on supply due to changes in the off-farm wage were especially of interest in this paper. Relationships between wages and hours worked depend upon complementarities and substitutions between leisure, farm work and off-farm work and are theoretically ambiguous. An advantage of the RCM is that parameters are allowed to vary and we may observe both positive and negative responses to wage rates. Table 3 shows variations that were observed for individual parameter estimates and elasticities from RCMs. Wage rates were found to be inversely related to the number of hours worked for MA operators and spouses and for PA spouses. However, PA operators were found to respond both negatively and positively. The effects of wages were statistically significant for MA operators and PA spouses. Increases in the off-farm wage apparently result in an allocation of more time to either the farm or leisure for most individuals. These results are consistent with farm family preferences for farm work or leisure over off-farm employment and suggests the use of off-farm employment to satisfy budgetary constraints.

Elasticities of hours worked with respect to wages were also calculated to indicates the usefulness of the RCM. Elasticities calculated from mean response coefficients for operators and spouses were inelastic. However, the elasticities for MA operators and PA spouses show that there is substantial variation in the responsiveness of individuals to wage changes. For MA farm operators, elasticities varied from a highly inelastic -0.04 to an elastic supply response of -2.15. PA farm spouses were also found to have a highly variable response to changes in the off-farm wage (-0.09 to -5.42). MA spouses were found to have a consistent

inelastic response to changes in the off-farm wage (-0.01 to -0.37). While the responses of PA operators were inelastic, both positive (0.17) and negative (-0.31) elasticities were observed.

Conclusions

Off-farm supply functions were estimated for operators and spouses using RCMs. The RCM provides predictions for individual parameters. Results were compared to standard fixed coefficient estimates which were adjusted for possible sample selection bias. Mean parameter vectors were found to be robust across estimation techniques. Thus, the random coefficients approach, with a different stochastic specification appears to perform well as an alternative to selectivity models. However, further investigation into the properties of random coefficients estimators under sample selection is needed. An important usé of the random coefficients results is in determining the variability of individual parameters. The variation in labor supply responses by farm operators and spouses to changes in the off-farm wage rate were presented in this paper. Responses by operators and spouses to changes in wages were found to vary both in the magnitude of the elasticity and in the sign of the elasticity. Thus, policy simulations based on standard fixed coefficient results could provide misleading results. The RCM model employed here provides further information on the random nature of family responses. This information is necessary to establish the distributional impacts of changing economic conditions on farm family welfare.

Table 1. Random Coefficients Estimates of Supply Functions for Farm Operators.

Variable	Massachusetts		Pennsylvania	
	RCM Mean	OLS	RCM Mean	OLS
Wage	-22.54*	-20.57*	2.97	-3.13
Individual Characteristics:				
Farm Exp.	-1.05	2.11	-4.07	1.62
Age	-13.44	-17.31*	3.74	-2.08
Education	40.10	29.38	-2.31	-1.74
Off-Farm Exp.	25.97*	20.00	14.35*	14.46*
Job Training	-499.65*	-451.02*	-231.24*	-117.90
Sex	682.06*	779.70*	a	a
Family Characteristics:				
Children ages < 5	-298.32*	-339.08*	190.95*	109.76
Children ages 5-18	132.83	107.12*	78.06*	50.30
Predicted Endogenous	-1518.49*	-1394.65*	287.61*	224.23
Farm Characteristics:				
Farm Sales	-598.30*	-671.44*	145.09*	186.88
Organization	2495.11*	2105.70*	b	b
Dairy	-725.52*	-1140.37*	-270.59*	-130.32*
Financial Characteristics:				
Other Income	7.16	5.92	-13.55*	-6.99*
Location:				
Commuting Distance	11.77*	8.31*	1.65	1.35
Unemployment	-77.93*	-101.46*	c	c
Lambda	NA	-57.40	NA	-755.18*

* - Statistically different from zero at the 5% level of significance.
a - Virtually all individuals were of the same sex.
b - Virtually none of the organizations were corporations.
c - Unemployment data by town not available for Pennsylvania.
NA - Not applicable.

Table 2. Random Coefficients Estimates of Supply Functions for Farm Spouses.

Variable	Massachusetts RCM Mean	Massachusetts OLS	Pennsylvania RCM Mean	Pennsylvania OLS
Wage	-8.55	-11.01	-24.63*	-19.51
Individual Characteristics:				
Farm Experience	-5.75	-8.99	2.64	4.94
Age	-24.25	-27.92*	-15.31	-31.65
Education	-79.25	-45.36	-41.52	-6.21
Off-Farm Experience	54.71	60.41*	31.42*	26.11*
Job Training	15.02	-151.75	-64.85	-31.96
Sex	-300.95	-512.01	a	a
Family Characteristics:				
Children ages < 5	-24.09	-48.90	22.16	-141.11
Children ages 5-18	-110.66	-127.07*	-123.34	-170.63
Predicted Endogenous	51.81	60.79	1077.60	682.79
Farm Characteristics:				
Farm Sales	-42.83	-0.29	285.75*	118.81
Organization	-152.41	-119.28	b	b
Dairy	-585.25	-605.87	-8.21	-127.75
Financial Characteristics:				
Other Income	12.80	9.66	11.70*	5.49
Location:				
Commuting Distance	-7.51	-15.19	10.73	5.62
Unemployment	-25.02	-14.48	c	c
Lambda	NA	-427.32	NA	126.98

* - Statistically different from zero at the 5% level of significance.
a - Virtually all individuals were of the same sex.
b - Virtually none of the organizations were corporations.
c - Unemployment data by town not available for Pennsylvania.
NA - Not applicable.

Table 3. Variation in Wage Elasticities of Supply and Parameter Estimates for Operators and Spouses.

	Elasticities			Parameter Estimates	
	Min	Mean	Max	Min	Max
Farm Operators:					
Massachusetts	-2.15	-0.25	-0.04	-25.72	-18.56
Pennsylvania	-0.31	0.02	0.17	-3.73	14.59
Farm Spouses:					
Massachusetts	-0.37	-0.07	-0.01	-9.91	-6.82
Pennsylvania	-5.42	-0.23	-0.09	-34.91	-20.08

Endnotes

1. Previous work on estimation of joint participation functions for the data sets used here did not support the hypothesis of joint off-farm decisions by farm operators and spouses.

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