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Farm Operator Off-farm Labor Supply and Hired Labor Use on Pennsylvania Farms

Introduction

Over time, the quantity of labor resources employed in U.S. agriculture has declined (Oliveira and Cox, Barkley), following the trend toward fewer and larger farms in the U.S. Adjustments in the allocation of labor to farm work in the U.S. have been studied in various contexts. Lass et al., Thompson, Huffman, Sumner, Gould and Saupe, Findeis and Reddy, Ahearn and Lee, McNamara and Gunter, and Rosenfeld, among many others, have examined time allocation decisions by farm operators, farm spouses, or both in the U.S. Research has also focused on the use of hired farm labor on U.S. farms (e.g., Martin, Emerson, Oliveira and Cox, Lopez, Gunter and Vasavada, and Nandkeolyar and Findeis). Typically the literature on off-farm work decisions has not dealt with the inter-relationships between family labor decisions (on-farm and off-farm) and the use of hired farm labor. Empirical studies that have analyzed hired farm labor decisions have either made strong separability assumptions regarding hired and family labor, or have not explicitly considered the relationships that may exist between family labor use (on-farm and off-farm) and hired labor decisions.

This research examines the interrelationships between farm operator off-farm labor supply and the use of hired labor. A two-stage approach suggested by Amemiya and based on Heckman's well-known two-stage model to correct for sample selection bias is used to examine: (a) principal farm operator off-farm labor supply under alternative conditions: when farms hire labor and when they do not, and (b) hired farm labor use, when the principal farm operator works off-farm and when the operator does not. The first stage involves estimation of a bivariate probit model of the potentially

simultaneous decisions of the farm operator to work off-farm and to hire labor. The second stage involves estimation of farm operator off-farm labor supply and hired labor use models, corrected for sample selection bias. When the off-farm work and hiring of labor decisions are not correlated, univariate probit models are estimated and used in the first stage.

All models are estimated using a sample of 989 Pennsylvania farm households surveyed in 1986-87.[1] Models are estimated separately for farms in rural-dominant labor market areas (LMAs) and in LMAs that are principally urban, following LeClere.[2] Heimlich and Barnard have shown that inherent differences exist in the type of farming and input intensity on rural versus urban farms. From a rural development perspective, it is also of interest to know to what extent differences in labor markets *in rural areas* influence off-farm work. Further, a comparison of the log-likelihood statistics of the restricted and unrestricted models (pooled versus not pooled) suggests that disaggregation of the data is warranted (Maddala).

Model Specification

Farm households are assumed to select levels of consumption (C) and leisure (L) that maximize utility (U), with household utility exogenously affected by the household's human capital (K) and other relevant exogenous variables (Z) that shift the utility function. Following Gronau, joint household leisure (L) is further disaggregated into the leisure of both spouses -- the principal farm operator (L_1) and farm spouse (L_2). The household utility function is constrained by the farm household's budget determined by consumption expenditures (P_cC), farm income ($P_qQ-P_xX-W_hH_h$), off-farm income of the farm operator and spouse ($W_1M_1 + W_2M_2$) and other income (Y_o) earned by the household. Farm income is a function of the farm

production function (Q), a function of operator and spouse farm labor (F_1 and $F_{2)}$, hired farm labor (H_h), and other inputs (X). The household's human capital (K) and other relevant exogenous variables (E) shift the production function. Further, utility is constrained by the total time available for work (on-farm (F_i) and off-farm (M_i)) and leisure (L_i) for the farm operator (i = 1) and farm spouse (i = 2).

Stated formally the model can be written as a maximization of

(1) $U = U(C, L_1, L_2; K, Z)$

subject to:

(2) $P_c C = P_q Q - P_x X - W_h H_h + W_1 M_1 + W_2 M_2 + Y_o$

(3) $Q = f(X, H_h, F_1, F_2; K, E)$, and

(4) $T_i = L_i + F_i + M_i$, $M_i \geq 0$ for $i = 1, 2$.

Simultaneous solutions to first-order conditions for maximization of (1) subject to (2)-(4) result in a complete set of demand and supply functions if there are no corner solutions. For example, the operator off-farm labor supply function is:

(5) $M_1 = M_1(W_1, W_2, W_h, P_c, P_q, P_x, Y_o, K, Z, E)$.

However, one or more choices may result in corner solutions. For example, the operator or spouse may not supply labor to off-farm markets. Models of these decisions are well known in the literature. Studies initially focused on farm operator decisions (i.e., Huffman, Sumner). Subsequent research has focused on joint off-farm participation and supply decisions by the farm operator and spouse (i.e., Huffman and Lange, Lass and Gempesaw).

Limitations of survey data typically preclude estimation of many household decisions. One decision that should be considered with the off-farm labor supply decisions is the choice of hired labor. This study focuses on

interactions between off-farm labor decisions of the farm operator and demand for hired labor. Given that corner solutions may arise in either the operator off-farm labor supply decision or the hired labor decision, four possible regimes exist:

(1′) $M_1 > 0$, $H_h > 0$ (operator works off-farm; labor is hired);

(2′) $M_1 > 0$, $H_h = 0$ (operator works off-farm; no labor is hired);

(3′) $M_1 = 0$, $H_h > 0$ (operator does not work off-farm; labor is hired); and

(4′) $M_1 = 0$, $H_h = 0$ (operator does not work off-farm; no labor is hired).

The appropriate reduced-form operator off-farm labor supply functions and hired labor functions are as follows. For the first regime, both operator off-farm labor supply and hired labor functions exist:

(6) $M_1^{1'} = M_1(W_1, W_2, W_h, P_c, P_q, P_x, Y_o, K, Z, E)$; and

(7) $H_h^{1'} = H_h(W_1, W_2, W_h, P_c, P_q, P_x, Y_o, K, Z, E)$.

In the second regime, only the operator off-farm labor supply function exists:

(8) $M_1^{2'} = M_1(W_1, W_2, P_c, P_q, P_x, Y_o, K, Z, E)$.

Because labor is not hired, the hired labor wage does not affect off-farm labor supply. For the third regime, only the hired labor demand function exists:

(9) $H_h^{3'} = H_h(W_2, W_h, P_c, P_q, P_x, Y_o, K, Z, E)$.

The operator's off-farm wage is not an argument in the hired labor demand function in this regime.

Consideration of interactions between operator and spouse off-farm labor supplies and spouse/hired labor decisions would lead to additional regimes. However, in the empirical application to Pennsylvania farm households below, only operator off-farm labor and hired labor decisions will be modeled for two reasons. First, Lass and Gempesaw analyzed the same data and found that

operator and spouse decisions were not made jointly. Thus, additional complexity resulting from interactions of farm operator/spouse off-farm labor decisions is not included. Second, breaking the data set into additional regimes to account for spouse/hired labor interactions would result in too few observations for estimation in some regimes. Effects of spouse decisions on hired labor are modeled in an ad hoc manner using participation binary variables for the spouse.

Empirical Model

A Heckman two-stage procedure can be applied to this problem using multiple selection rules (see Amemiya, Killingsworth). The procedure provides consistent estimates of operator off-farm labor supply and hired farm labor use under alternative regimes.

Whether the farm operator participates in off-farm work or not will depend on the difference between the market wage (W_1) and the shadow value of farm labor when $M_1 = 0$ (hours of off-farm work equals 0). If the market wage (W_1) exceeds the shadow value of operator time allocated to farming, the operator will allocate hours to off-farm work (i.e., $M_1 > 0$). If not, no off-farm work will be observed ($M_1 = 0$). Conversely, no farm labor will be hired if the hired labor wage is greater than the marginal value of hired labor in farm work. Participation decision rules for operator off-farm work and for the hiring of labor for the i farm households in the sample are as follows:

$$(10)\quad M_{1i} > 0 \text{ if } I^*_{1i} = \gamma'_{1i}\alpha_1 + \varepsilon_{1i} > 0$$
$$= 0 \text{ if } I^*_{1i} = \gamma'_{1i}\alpha_1 + \varepsilon_{1i} \leq 0$$

$$(11)\quad H_{hi} > 0 \text{ if } J^*_{hi} = Z'_{hi}\delta_1 + \varepsilon_{hi} > 0$$
$$= 0 \text{ if } J^*_{hi} = Z'_{hi}\delta_1 + \varepsilon_{hi} \leq 0$$

where I_{1i}^* represents the *unobserved* difference between the operator's value of time off-farm and on-farm and J_{hi}^* is the *unobserved* difference between the value of hired labor on-farm and the hired labor wage.

The *observed* differences can be represented by a dichotomous dependent variable model that defines the binary values of I_{1i} and J_{hi} as follows:

$$(12)\quad I_{1i} = 1 \text{ if } I_{1i}^* = \gamma_{1i}'\alpha_1 + \varepsilon_{1i} > 0$$
$$= 0 \text{ if } I_{1i}^* = \gamma_{1i}'\alpha_1 + \varepsilon_{1i} \leq 0$$
$$(13)\quad J_{hi} = 1 \text{ if } J_{hi}^* = Z_{hi}'\delta_1 + \varepsilon_{hi} > 0$$
$$= 0 \text{ if } J_{hi}^* = Z_{hi}'\delta_1 + \varepsilon_{hi} \leq 0$$

A bivariate probit model can be used to estimate these potentially simultaneous decisions in the first stage, with the Heckman procedure used to correct for sample selection bias through inclusion of correction factors in the operator labor supply and hired labor use functions.[3] When the dichotomous dependent variable models are not correlated, univariate probit models are used, with estimated correction factors again used to correct for sample selection bias in the second stage. Sample selection bias, if left uncorrected, will result from the selection of data based on (1) whether or not an operator works off-farm and (2) whether labor is hired or not.

The second stage of the model then involves estimation of the operator's off-farm labor supply and hired labor use functions, conditional upon the decisions modeled in the first stage. For operator labor supply and hired labor use the conditional functions can be written as follows, with $X_i^{1'}$, $X_i^{2'}$, $X_i^{3'}$ representing the exogenous variables for each of the three relevant regimes (i.e., 1′, 2′, 3′), including corrections for sample selection bias:

$$(14) \quad M_{1i}^{1} = X_i^{1\prime}\beta_1^1 + \mu_{1i}^1$$

$$(15) \quad M_{1i}^{2} = X_i^{2\prime}\beta_1^2 + \mu_{1i}^2$$

$$(16) \quad H_{2i}^{1} = X_i^{1\prime}\beta_2^1 + \mu_{2i}^1$$

$$(17) \quad H_{2i}^{3} = X_i^{3\prime}\beta_2^3 + \mu_{2i}^3$$

The operator labor supply functions are estimated based on equations (14) and (15), using data from farm households that hire labor (eq. 14) or do not (eq. 15). The vectors β_1^1 and β_1^2 represent the estimated coefficients for the exogenous variables in the operator off-farm labor supply functions. In equation (14) the effects of hired labor wage on the operator's off-farm labor supply is incorporated.

Equations (16) and (17) represent the hired labor use functions, conditional on whether the farm operator works off-farm (eq. 16) or not (equation 17). The vectors β_2^1 and β_2^3 represent the estimated coefficients for the regime-specific samples, with β_2^1 including an operator wage variable representing the effects of the operator's observed off-farm wage on hired labor use.

Data

The 1986-87 survey of Pennsylvania farm households provides data on the off-farm work of principal farm operators and spouses, and on the use of hired farm labor. The data on hired farm labor are disaggregated into labor hired (1) full-time throughout the year, (2) part-time throughout the year, or (3)

on a seasonal basis. Data are available on wages received by operators and spouses in the nonfarm labor market and wages paid for hired labor, as well as time allocations of farm operators and spouses to off-farm work and quantities of labor hired. Data on principal farm operator characteristics, the characteristics of the farm household, and selected characteristics of the farm operation are also available from the survey.

Further, to examine the influence of labor market conditions on off-farm work and the use of hired labor, the survey data are supplemented with data on local labor market area conditions derived from the Regional Economic Information System (REIS) of the Bureau of Economic Analysis. The REIS data were made compatible with local labor market areas defined for the U.S. by Tolbert and Killian, and merged with the survey data. Based on McNamara and Gunter, Gunter and McNamara and LeClere, the unemployment rate, average annual nonfarm earnings and the proportion of LMA employment in selected alternative major industries (i.e., manufacturing; consumer services; finance, insurance, and real estate; and wholesale and retail trade) were incorporated as exogenous variables.[4] All location-related variables were defined on an LMA basis.

Of the 989 farms surveyed, 399 farms were classified as being located in labor market areas comprised principally of nonmetropolitan counties, and 590 were in LMAs that included principally metropolitan counties, based on Census MSA definitions. Of the farms located in rural-dominant LMAs, 14% hired full-time farmworkers, compared to only 9% of farms in urban-dominant LMAs. Twelve percent of rural farms hired part-time, year-round labor and 28% hired seasonal labor. This compares to 12% and 31% for part-time, year-round labor and seasonal workers, respectively, in urban-dominant LMAs.

Table 1 provides mean values of selected characteristics associated with farms that hire labor and those that do not, by rural-dominant and urban-dominant LMA location. Not surprisingly, farms that hired labor were larger in terms of value of annual farm sales and tillable acres. Farms that hired labor were also more likely to be organized as corporations or partnerships, rather than as household operated family farms. Dairy farms were more likely to hire labor, regardless of rural/urban location. Further, farms with farm labor were more likely to do custom farm work for others.

Joint Decisions

Univariate and bivariate probit models for farm operator participation in off-farm work and the hiring of farm labor were estimated in the first stage. The correlation between the decisions to hire farm labor and to work off-farm are shown to be at least marginally significant ($t = -1.805$) in the urban-dominant model, and thus the bivariate probit estimates are used for the urban-dominant models. The negative correlation indicates that in urban-dominant areas the decision to hire labor *reduces* the likelihood that the operator works off-farm. That is, operator labor and hired farm labor are complementary. For farms located rural-dominant LMAs, no relationship was found. Given these test results, Tables 2 and 3 include the bivariate probit model estimates for farms in urban-dominant LMAs and the univariate estimates for rural farms.

The factors found to affect the operator's decision to work off-farm include: operator's age (and an age-squared variable), off-farm employment of the farm spouse (in rural areas). annual farm sales, and dairy as the principal enterprise (see Table 2). There is growing consensus, based on research on work decisions, that the operator's likelihood of working off-farm

changes through the life-cycle, such that the likelihood initially increases with age and then declines. Further, research consistently shows that the size of the farm is inversely related to the likelihood of off-farm work by the operator, and that dairy farmers are less likely to work off-farm. The variables found to be statistically significant in Table 2 suggest that differences in the operator's characteristics and the characteristics of the farm (that affect the time required for farming) are more influential on the operator's decision to work off-farm than are local labor market characteristics. Variations in the LMA unemployment rate or average annual nonfarm earnings were not related to the operator's likelihood of off-farm work. In addition, the industrial structure of the local labor market was not found to be an important factor influencing off-farm work participation, but it is perhaps more reasonable to expect that local industrial structure should influence not *whether* an operator works off-farm but the *characteristics of this work*. The latter will likely be reflected in the days or hours of work the operator supplies to off-farm employment.

As shown in Table 3, farm size (proxied by the value of annual farm sales) has a significant effect on the decision to hire labor in both urban-dominant and rural-dominant farm locations. Other variables shown to be important include variables associated with work (other than farming on own farm) of both the principal farm operator (i.e., custom farm work) and the farm spouse (i.e., off-farm work in rural LMAs). And, as previously discussed, the hiring of farm labor was shown to be weakly correlated with the operator's off-farm work decision in urban-dominant locations. No statistically significant relationships were shown to exist between the use of hired farm labor and the labor market variables. However, the significance of

the variable reflecting off-farm work by the spouse in both the operator off-farm work and hired labor probit equations implies that interesting relationships may exist (at least in rural areas) between the work decisions of the operator and spouse and the use of hired farm labor.

Off-farm Labor Supply

Using the estimates in Tables 2 and 3, the second stage coefficients of operator labor supply were estimated separately for farms that hire labor and those that do not, in urban-dominant and rural-dominant locations. The equation for each model was corrected for sample selection bias to compensate for the existence of corner solutions, i.e. farm operators that do not work off-farm, or farm operations that do not hire labor inputs.

Table 4 indicates a consistency in the *direction* of effects of off-farm wage and hired labor wage on the off-farm labor supply of Pennsylvania farm operators. Although not statistically significant, the wage coefficients had the anticipated signs: positive for operator off-farm wage and negative for hired labor wage. Further, although the characteristics of the farm operator were important factors affecting the operator's decision to work off-farm, these characteristics (e.g., age) were less likely to be important predictors of labor supply. The only exception was the off-farm work experience of the operator; for farms with hired labor, the operator's years of off-farm work had a positive effect on the days worked off-farm.

The characteristics of the farm household are more likely to affect the operator's off-farm labor supply. When the spouse also works off-farm, the farm operator allocates more time to off-farm employment if the farm hires labor. However, at least in urban locations, the opposite occurs when supplemental labor is not hired; if the spouse works off-farm on urban farms

with no hired labor, the principal operator will work fewer days off-farm, and likely spend more time doing farm work. Further, the number of older children, while not an important indicator of operator off-farm work participation, was found to be related to the days worked off-farm for operators on farms hiring labor in rural locations. Older children appear more likely to influence the operator's off-farm labor supply when supplementary labor is hired, and the effects are greater than when no labor is hired. Work performed by older children is more likely to influence operator off-farm work time on farms with hired labor perhaps because these farms tend to be larger and require more on-farm labor. If labor is hired and children can provide additional labor to work larger farms, the operator is able to spend more days off-farm.

Finally, the local labor market variables are found to be more important for influencing labor supply than for affecting operator participation in off-farm work, in urban areas at least. In both urban-dominant and rural-dominant LMAs, a greater proportion of manufacturing jobs means more time spent working off-farm by the farm operator, at least on farms without hired labor. When manufacturing provides a greater proportion of LMA employment, there may be more full-time jobs than when an economy is more heavily reliant on service industry employment.

Hired Labor Use

A similar procedure was used to estimate hired labor use functions as that used to estimate the off-farm labor supply models of farm operators, with one exception -- separate models were estimated (when possible) for (a) labor employed either full-time or part-time throughout the year and (b) labor working on a seasonal basis. Significant differences exist in the

characteristics of work performed by each type of labor, and the timing of this work. Separate functions were estimated for each labor classification to reflect these differences, and to serve as a control for worker characteristics (e.g., farm experience, race, and citizenship), not available from the survey. Because the probit functions used to estimate the correction factors for hiring of labor are estimated on the basis of *all hired labor*, it is assumed that the selection bias is approximately identical for farms hiring full-year labor and those hiring only seasonal labor.

The exogenous variables in the hired labor functions include factors potentially influencing the supply of hired labor and the demand for full-year and seasonal farmworkers. The annual value of farm sales, farm organization, principal farm enterprise, and the farm household variables reflect demand factors. The larger the farm and the more labor intensive the principal enterprise, the more hired labor will be used. Dairy farms are expected to require more full-year labor whereas fruit, vegetable and nursery farms are expected to use more seasonal labor. In addition, the characteristics of the farm household are anticipated to affect hired labor demand. When the spouse does not work off-farm or when there are more older children in the household, it is anticipated that less labor will be hired.

Conversely, local labor market conditions are expected to influence the supply of hired labor to farms in Pennsylvania. The higher the unemployment rate in an LMA, the more likely local labor resources will be available for farm work. The industrial structure of the labor market may also influence hired labor supply. As discussed in Gunter and McNamara, the service sector is more likely to provide part-time work, either part-day or part-year. In economies that rely more heavily on service industry employment, there may be

more labor available for seasonal farm work or for part-time, full-year work. Alternatively, when there is a heavier reliance on manufacturing, more full-time employment exists with less labor available for seasonal farmwork.

Tables 5 and 6 include the hired labor use functions for farms where the principal farm operator works solely on-farm (Table 5) and when the operator works off-farm (Table 6). On urban farms where the operator does not work off-farm, farm size is related to the use of full-year labor; the larger the farm, the more hours of full-year labor is hired. Dairy farms also hire more full-year labor under these conditions, and the greater the number of older children on the farm, the less labor is hired on a year-round basis. In urban areas, operator labor and hired labor appear to be weak complements, but labor by older children may be substituted for hired labor. The trade-off between child labor and hired year-round labor may be a reflection of the greater difficulty urban farms have finding hired labor (Findeis and Bowser).

On urban farms where the operator works solely on-farm, fruit, vegetable and nursery operations required more seasonal labor, as anticipated. Seasonal labor was also more likely to be hired on urban farms that were incorporated or were operated as partnerships. Further, farms in urban areas with more (low-wage) service industry employment hired less seasonal labor. In urban areas where (low-wage) service employment is more prevalent, migrant workers may be more likely to have alternative employment in the service industries. This may also be the situation for students that at one time provided a good source of labor for harvest. It is likely that growth in service industry employment has contributed to the sharp decline in the numbers of part-year farmworkers that has occurred in the past decade.

On rural farms where the operator does not work off-farm, the quantity of full-year hired labor used by farms is influenced by the size of the farm (positive), dairy as the principal enterprise (positive), the number of older children (negative), off-farm work by the spouse (positive), and a higher proportion of local labor market employment in the service industries (positive). For seasonal labor, farm organization was again a relevant predictor as was the operation of a fruit, vegetable or nursery crop farm. Interestingly, in rural areas, greater reliance on (low-wage) service industry employment is found to *positively* affect the use of full-year hired farm labor. In rural economies, the service industries may provide less employment throughout the year, allowing farms to hire this underemployed workforce. Hired farm labor may be more likely in rural as compared to urban areas to be employed in *both* farm and nonfarm work during the year, with service sector employment facilitating this arrangement and possibly helping to maintain more farm labor in rural areas. The competition between service industry employment and employment in agriculture may be less severe in rural areas than in urban economies.

Table 6 includes hired labor equations for hired labor in urban-dominant and rural-dominant LMAs, where the operator works off-farms. Due to the limited number of farms where both labor is hired and the principal farm operator works off-farm, it was not possible to disaggregate the sample into full-year and seasonal labor. Therefore, the hired labor models in Table 6 reflect an aggregation of all types of labor. As shown in Table 6, when the farm operator works off-farm in a rural area, the quantity of hired labor employed on the farm is influenced by dairy as the principal enterprise (positive), custom work by the operator (positive), off-farm work by the farm

spouse (positive) and (low-wage) service industry employment (positive). Interestingly, for rural areas, the factors shown to be relevant indicators of hired labor use are similar regardless of whether the operator works off-farm or not.

However, for urban areas, none of the variables hypothesized to affect the quantity of hired labor employed were found to be significant. This may be due in part to a high degree of collinearity between variables, although this result may also mean that other factors better explain variations in hired labor use by urban farm operators who simultaneously work off-farm.

Conclusions

This research has raised several interesting issues that should be pursued in different contexts and, perhaps, using a larger data set. First, to what extent are the decisions to work off-farm and to hire labor interrelated on U.S. farms? This research indicates that these decisions may be at least weakly interrelated in some contexts. In Pennsylvania, larger farms in urban areas are more likely to require hired labor as well as all of the operator's worktime. Although it might have been expected that smaller, urban "hobby" farms would hire labor to substitute for operator work on-farm, this was not found to be the case. Further, in rural locations, the operator's off-farm work decision and the decision to hire labor were not found to be joint decisions, but the significant coefficients for spouse off-farm work in the rural off-farm labor participation and use of hired labor models suggest that there may be interesting and potentially important relationships between the off-farm work decisions by both the operator and spouse and the use of hired labor. It would be possible to examine these relationships using the trivariate methods applied in Findeis.

Second, should hired labor be treated as homogeneous when examining factors related to hired labor use? This research has shown that the factors influencing the use of year-round versus seasonal farm labor differ significantly and predictably. Future research should assess whether full-year and seasonal labor have different effects on the operator's and/or spouse's decisions to work off-farm. Relationships between off-farm work and hired labor decisions may be clouded by the aggregation of full-year and seasonal hired labor into "all hired labor."

Finally, to what extent do local labor markets affect off-farm work and hired labor use decisions? Findeis et al. raised this question previously, and research by McNamara and Gunter, Gale, Corsi, and others have recently attempted to provide a more indepth understanding of the impacts of local labor markets on the utilization of or returns to labor resources in agriculture. This paper suggests that local labor market structure is more likely to influence operator off-farm labor supply and levels of hired labor use, than the decisions to work off-farm or to hire labor. The latter decisions are more likely to be influenced by the labor needs of the farm itself. The influence of the local labor market appears to be through the characteristics of the jobs that provide farm operators with work off-farm or provide hired labor either with alternative employment or another part-time job to supplement part-time employment in agriculture.

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Footnotes

1. Hallberg, Findeis and Lass (1987) provides a description of the 1986-87 survey, and a summary of the descriptive results.

2. The terms "metropolitan" and "urban" will be used interchangeably in this paper as will "nonmetropolitan" and "rural."

3. See discussion in appendix to Lass and Gempesaw.

4. The service industries were disaggregated because of the large variation in the characteristics of work in this industry.

Table 1. Mean Characteristic Values for Farm Households in Urban-dominant and Rural-dominant Labor Market Areas, Pennsylvania.

Variable	Farms in Urban-dominant Labor Market Areas		Farms in Rural-dominant Labor Market Areas	
	With Hired Labor n=229	Without Hired Labor n=361	With Hired Labor n=150	Without Hired Labor n=249
Farm Household Characteristics				
Operator age (years)	49.63	52.90	48.77	52.18
Operator education (years completed)	12.54	12.26	12.15	12.19
Sex of operator (1=male)	0.70	0.70	0.83	0.81
Spouse age (years)	47.79	49.74	46.94	50.13
Spouse education (years completed)	12.38	13.12	13.15	13.19
Number or presence of children:				
< 5 years (presence; 1=yes)	0.14	0.14	0.14	0.09
5-18 years (number)	0.66	0.70	0.73	0.63
Characteristics of Work by Household				
Operator works off-farm (1=yes)[a]	0.29	0.47	0.35	0.45
Average hours of off-farm work	39.58	41.41	39.78	41.39
Works off-farm year-round (1=yes)	0.81	0.85	0.87	0.79
Average hours of on-farm work	23.90	25.37	29.65	21.95
Years of off-farm experience	23.09	23.53	20.17	22.93
Spouse works off-farm (1=yes)[b]	0.25	0.25	0.25	0.23
Average hours of off-farm work	37.65	34.43	36.08	35.24
Works off-farm year-round (1=yes)	0.77	0.78	0.63	0.54
Average hours of on-farm work	14.13	19.15	15.52	19.32
Years of off-farm experience	13.91	14.31	13.95	15.49
Operator or spouse does custom work (1=yes)	0.27	0.12	0.26	0.12
Farm Characteristics				
Tillable acres	163.95	120.20	234.78	112.87
Principal farm enterprise:				
Dairy (1=yes)	35.8	19.9	44.7	30.2
Field crops (1=yes)	17.9	22.7	12.7	18.5
Fruit, vegetables, or nursery crops (1=yes)	14.3	12.8	10.0	10.5
Livestock (1=yes)	17.9	24.9	14.6	22.9
Forestry, Christmas trees (1=yes)	0.4	1.1	1.3	2.8
Annual farm sales:				
< $40,000	49.0	54.7	45.5	58.3
$40,000 - $100,000	26.7	29.9	21.2	17.6
Over $100,000	24.3	15.4	33.3	24.1
Farm organization:				
Single household (1=yes)	0.80	0.91	0.81	0.93
Processing on-farm (1=yes)	0.14	0.12	0.17	0.07
Local Labor Market Area (LMA) Variables				
Average unemployment rate in LMA (%)	7.35	7.72	9.13	9.02
Average annual nonfarm earnings in LMA ($)	11,563.00	11,659.00	9,122.00	9,577.00
Percent of LMA employment in				
Manufacturing	20.06	19.83	24.65	24.63
Services (low-wage)	24.78	24.94	22.03	22.03
Trade	22.48	22.41	19.77	19.91
Services (high-wage)	5.88	5.85	4.68	4.71

[a] All indented characteristics are only for operators that work off-farm.
[b] All indented characteristics are only for spouses that work off-farm.

Table 2. Probit Estimates for Off-farm Work by Principal Farm Operator.

Variable	Urban-dominant Bivariate Model	Rural-dominant Univariate Model
Characteristics of Principal Farm Operator	n=513	n=343
Age	0.0954*	0.1507*
	(6.862)	(2.422)
Age-squared	-0.0014*	-0.0020*
	(-7.869)	(-3.209)
Years of Education	0.0303	0.0203
	(1.085)	(1.258)
Sex (1=male)	0.0084	0.2394
	(0.051)	(0.947)
Characteristics of Farm Household		
Spouse Works Off-farm (1 = yes)	0.2649	0.5514*
	(1.598)	(2.583)
Number or Presence of Children		
< 5 years (presence; 1=yes)	-0.0974	-0.4482
	(-0.437)	(-1.482)
5-18 years (number)	-0.0055	0.0858
	(-0.077)	(0.853)
Annual Farm Sales (categorical)	-0.5679*	-0.6898*
	(-7.772)	(-6.422)
Farm Organization (1 = corporation/partnership)	0.2245	-0.2420
	(0.881)	(-0.686)
Principal Enterprise:		
Dairy (1=yes)	-0.7116*	-0.9888*
	(-3.714)	(-4.025)
Field Crops (1=yes)	0.1467	0.2107
	(0.733)	(0.832)
Vegetables, Fruits, or Nursery Crops (1=yes)	0.1594	-0.0177
	(0.692)	(-0.058)
Labor Market Characteristics		
Unemployment Rate in LMA	0.1964	0.0398
	(1.141)	(0.457)
Average Annual Nonfarm Earnings in LMA	0.0011	-0.00008
	(0.821)	(-0.624)
Proportion of LMA Employment in:		
Manufacturing	0.2906	-0.0528
	(1.609)	(-1.785)
Low-wage Services	0.0110	0.0348
	(0.134)	(0.218)
Trade	1.0095	-0.4753
	(1.399)	(-1.079)
High-wage Services	-0.2151	0.0392
	(-0.239)	(0.671)
Intercept	-29.5734	5.6590
	(-1.502)	(0.648)
Rho (1,2)	-0.1671	not app.
	(-1.805)	
Goodness-of-fit		
Log-likelihood	-531.66	-132.78

*Statistically different from zero at the 5% level of significance or better. Asymptotic t-statistics are presented in parentheses.

Table 3. Probit Estimates for Use of Hired Farm Labor.

Variable	Urban-dominant Bivariate Model	Rural-dominant Univariate Model
Characteristics of Farm Operation	n=513	n=343
Annual Farm Sales (categorical)	0.4740*	0.5215*
	(6.754)	(5.938)
Farm Organization (1 = corporation/partnership)	0.1076	0.0477
	(0.595)	(0.195)
Principal Enterprise:		
Dairy (1=yes)	0.0204	-0.2898
	(0.110)	(-1.389)
Field Crops (1=yes)	-0.0141	-0.1714
	(-0.081)	(-0.744)
Vegetables, Fruits, or Nursery Crops (1=yes)	0.2350	-0.0218
	(1.090)	(-0.080)
Characteristics of Farm Household		
Custom Work by Operator (1=yes)	0.3735*	0.4826*
	(2.569)	(2.550)
Operator Age > 65 (1=yes)	-0.0344	0.3729
	(-0.180)	(1.539)
Number of Children 5-18	-0.0557	-0.0041
	(-0.910)	(-0.054)
Spouse Works Off-farm (1=yes)	-0.0073	0.4265*
	(-0.273)	(2.372)
Labor Market Characteristics		
Unemployment Rate in LMA	-0.0505	-0.567
	(-1.546)	(-0.911)
Proportion of LMA Employment in:		
Manufacturing	-0.0073	-0.0167
	(-0.273)	(-0.945)
Low-wage Services	0.0317	0.0226
	(1.047)	(0.578)
Intercept	-1.5197	-2.1541
	(-1.239)	(-1.733)
Rho (1,2)	-0.1671	not app.
	(-1.805)	
Goodness-of-fit:		
Log-likelihood	-531.66	-193.09

*Statistically different from zero at the 5% level of significance or better. Asymptotic t-statistics are presented in parentheses.

Table 4. Operator Off-farm Labor Supply Functions for Farms Hiring and Not Hiring Farm Labor.

	Urban-dominant		Rural-dominant	
Variable Y=Days of Work Off-farm (8-hour)	With Hired Labor n=41	No Hired Labor n=99	With Hired Labor n=26	No Hired Labor n=73
Wages				
Ln(Wage) - Operator	36.0850 (1.324)	12.6776 (1.277)	58,1270 (1.670)	19.7720 (1.003)
Ln(Wage) - Hired Labor[a]	-22.7088 (-1.015)	–	-29.5281 (-0.831)	–
Characteristics of Operator				
Age	1.9030 (0.882)	1.5540* (2.355)	1.3904 (0.564)	1.0991 (1.180)
Years of Education	2.2532 (0.497)	0.7344 (0.379)	-12.7608 (-1.320)	1.4359 (0.465)
Off-farm Work Experience (years)	0.3397** (1.949)	0.6766 (1.128)	0.7245** (2.064)	0.5082 (1.028)
Characteristics of Farm Household				
Spouse Works Off-farm (1=yes)	57.3951** (1.758)	-23.6516* (-2.022)	142.898** (1.921)	-0.7734 (-0.028)
Number of Children 5-18	15.3040 (1.425)	2.8411 (0.610)	74.7707** (1.994)	3.8559 (0.457)
Other Income	-0.0068 (-0.337)	-0.0034 (-0.333)	-0.0032 (-0.054)	-0.0081 (-0.585)
Characteristics of Farm Operation				
Annual Farm Sales (categorical)	-36.9040 (-0.976)	-33.2539 (-1.524)	-12.3004 (-0.169)	-29.0179 (-1.101)
Farm Organization (1=corp./part.)	-30.5266 (-1.115)	4.0557 (0.188)	96.7809 (0.813)	-16.5140 (-0.588)
Dairy Farm (1=yes)	-173.590* (-2.296)	-19.4255 (-0.459)	-54.5337 (-0.694)	-81.9413* (-2.748)
Labor Market Characteristics				
Average Annual Nonfarm Earnings in LMA	0.0077* (2.153)	0.0035* (2.151)	0.0168 (0.641)	-0.0051 (-0.598)
Proportion of LMA Employment in:				
Manufacturing	-4.9128 (-0.410)	4.5579** (1.894)	12.6276 (1.332)	14.9541* (2.021)
Low-wage Services	6.4214 (0.686)	-1.9640 (-0.397)	47.0497 (1.273)	3.4271 (0.282)
Trade	-7.1102 (-0.147)	37.8328** (1.984)	35.0432 (0.404)	9.2574 (0.331)
High-wage services	-35.8253 (-0.691)	-8.2790 (-0.335)	-191.479 (-1.300)	-14.3475 (-0.105)
Intercept	483.983 (0.387)	-626.943 (-0.949)	624.394 (0.356)	19.551 (0.036)
λ_1 (off-farm work decision)	191.641 (1.677)	-101.682* (-3.728)	56.6875 (0.649)	9.4320 (0.396)
λ_2 (hired labor decision)	93.8563 (1.325)	98.2343** (1.881)	260.126 (1.787)	-35.9527 (-0.419)
Goodness-of-fit: Adjusted R^2	0.3006	0.3468	0.4421	0.2609

[a]The wage variable for hired labor when more than one farmworker is hired is equal to the weighted sum of the wages paid to multiple workers, with the weights determined by the time worked.

* Statistically different from zero at the 5% level of significance or better.
**Statistically different from zero at the 10% level.

Table 5. OLS Hired Labor Functions for Farms Where Principal Farm Operator Does Not Work Off-farm.

	Urban-dominant		Rural-dominant	
Variable Y = Hours of Hired Labor Use	Full-year[a] Hired Labor n = 102	Seasonal Hired Labor n = 149	Full-year[a] Hired Labor n = 76	Seasonal Hired Labor n = 85
Characteristics of Farm Operations				
Annual Farm Sales (categorical)	7283.99**	-210.843	20433.8*	347.97
	(1.859)	(-0.370)	(2.580)	(1.498)
Farm Organization (1 = corporation/partnership)	2894.6	646.386*	2408.4	472.3**
	(0.964)	(2.613)	(0.927)	(1.708)
Principal Enterprise:				
Dairy (1 = yes)	12156.6**	-380.374	7028.5*	-206.96
	(1.884)	(-1.387)	(2.215)	(-0.808)
Fruits, Vegetables, and Nursery Crops (1 = yes)	-14769.2	1629.40*	-6990.8	611.8**
	(-1.253)	(4.034)	(-1.438)	(1.951)
Field Crops (1 = yes)	-2957.13	-67.3286	8340.25	183.2
	(-0.995)	(-0.234)	(1.198)	(0.667)
Characteristics of Farm Household				
Custom Work by Operator (1 = yes)	69.2630	-845.323	1526.3	451.6
	(0.262)	(-1.115)	(0.419)	(1.467)
Number of Children 5-18	-566.188*	85.2609	-5590.9*	55.56
	(-2.262)	(0.668)	(-2.537)	(0.605)
Spouse Works Off-farm (1 = yes)	3257.27	-178.257	12659.2*	329.2
	(0.480)	(-0.746)	(2.262)	(0.872)
Labor Market Characteristics				
Proportion of LMA Employment in:				
Manufacturing	191.409	-29.0119	595.460	-2.2595
	(0.306)	(-0.646)	(1.441)	(-0.112)
Low-wage Services	-266.520	-97.4261**	2286.5*	75.9820**
	(-0.733)	(-1.883)	(2.548)	(1.753)
Unemployment Rate in LMA	827.192**	67.3323	1727.7	116.272**
	(1.687)	(1.026)	(1.574)	(1.825)
Intercept	53997.7	5741.59	-1807.1*	-4812.2*
	(1.174)	(1.027)	(-2.583)	(-2.033)
ϕ_1 (off-farm work decision)	191.409	-225.405	857.0	1.7844
	(0.306)	(-1.458)	(0.330)	(0.014)
ϕ_2 (hired labor decision)	-266.520	-2067.50	28157.0*	1290.1
	(-0.733)	(-0.822)	(2.201)	(1.142)
Goodness-of-fit:				
Adjusted R^2	0.3306	0.2828	0.4406	0.1830

[a]Includes full-time and part-time labor.

*Statistically different from zero at the 5% level of significance or better.
**Statistically different from zero at the 10% level

Table 6. OLS Hired Labor Functions for Farms Where Principal Farm Operator Works Off-farm.

Variable Y=Hours of Hired Labor Use	Urban-dominant All Hired Labor n=41	Rural-dominant All Hired Labor n=26
Characteristics of Farm Operation		
Annual Farm Sales (categorical)	-590.087	4877.01
	(-0.297)	(1.094)
Farm Organization (1=corporation/partnership)	-187.520	248.889
	(0.256)	(0.107)
Principal Enterprise:		
Dairy (1=yes)	645.691	2762.79**
	(0.518)	(1.885)
Fruits, Vegetables, or Nursery Crops (1=yes)	933.590	1569.59
	(0.703)	(1.321)
Field Crops (1=yes)	124.971	-1324.73
	(0.288)	(-0.692)
Characteristics of Farm Household		
Custom Work by Operator	-585.578	4852.70**
	(-0.341)	(1.879)
Number of Children 5-18	43.2699	392.990
	(0.136)	(0.663)
Spouse Works Off-farm (1=yes)	-446.367	3724.68**
	(-0.809)	(1.958)
Labor Market Characteristics		
Unemployment Rate in LMA	128.398	477.498
	(0.481)	(0.830)
Proportion of LMA Employment in:		
Manufacturing	21.6426	-147.228
	(0.239)	(-0.843)
Low-wage Services	-30.3805	345.492**
	(-0.181)	(1.960)
Ln(Wage) - Operator (hourly)	414.475	206.090
	(0.988)	(0.373)
Intercept	1990.76	-35092.5
	(0.167)	(-1.185)
τ_1 (off-farm work decision)	-326.177	110.842
	(-0.303)	(0.087)
τ_2 (hired labor decision)	-2503.44	14054.7
	(-0.390)	(1.053)
Goodness-of-fit:		
Adjusted R^2	0.3988	0.4755

*Statistically different from zero at the 5% level of significance or better.
**Statistically different from zero at the 10% level.