THE HOURLY LABOR SUPPLY RESPONSE OF AGRICULTURAL WORKERS

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A number of economic policies are believed to influence an individual's decision of how many hours or weeks to work. Among these policies are welfare programs, income maintenance plans, and unemployment insurance. To date, questions of agricultural labor response to economic incentives have been analyzed by resorting to aggregate data and models, typically utilizing state or U.S. time series data.[1] While this does provide needed information for analysis of some policies, aggregate data and models are deficient in isolating substitution and income effects. These are necessary for analysis of particular programs affecting only income or affecting the individual's budget constraint in a discontinuous way. In particular, aggregate models cannot approach the question of a backward bending supply curve, since aggregate data include not only variations in duration of employment but also variations in labor force participation.

The paper focuses on labor supply at the micro level, presenting estimates of labor supply parameters for use in analyzing alternative economic policies directed toward agricultural labor markets.

THE ECONOMIC MODEL

The standard income-leisure analytical framework is assumed with a twice differentiable concave utility function in goods (X) and leisure (Z), U(X, Z).[2] The individual is assumed to maximize U(X, Z) subject to budget and time constraints, respectively:

$$(1)\quad \begin{cases} X = LW + Y_n \\ L = T - Z \end{cases}$$

where W is the wage rate, Y_n is non-employment income, L is working time, and T is total time available. Maximization of the appropriate Lagrangian,

$$(2)\quad G = U(X, Z) - \lambda \{X - (T - Z)W - Y_n\}$$

yields the first order conditions:

$$(3)\quad \begin{cases} U_x = \lambda \\ U_z = \lambda W \\ X = (T - Z)W + Y_n. \end{cases}$$

Solution of equations (3) for L yields the labor supply function

$$(4)\quad L = L(W, Y_n).$$

The familiar Slutsky equation is obtained by differentiating the first order conditions (3) with respect to W and Y_n and solving for $\partial L/\partial W$ and $\partial L/\partial Y_n$:

$$(5)\quad \frac{\partial L}{\partial W} = \frac{\partial L}{\partial Y_n}\bar{L} + \frac{\partial L^S}{\partial W}$$

where $\partial L/\partial W$ is the total effect of a change in the wage rate. The total effect is decomposed into an income effect, $(\partial L/\partial Y_n)\bar{L}$, where $\bar{L}$ is the equilibrium labor supply, and a substitution effect, $\partial L^S/\partial W$. The latter term is unambiguously positive, given that the utility function is concave whereas the sign of the income effect is ambiguous and requires empirical evidence. Although the income effect is typically assumed to be negative (assuming leisure is a normal good), only its ob-

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[1] Examples of such studies are Schuh [8] and Tyrchniewicz and Schuh [10].

[2] A more detailed presentation and rationale for this type of model may be obtained in Kosters [4] and Perlman [7].

served magnitude relative to the substitution effect will resolve whether or not the labor supply curve is backward bending.

THE EMPIRICAL MODEL

The Data

Since what can be done in econometric work is often strongly influenced by available data, let us first examine what is available for an analysis of weekly hours of work. The data base is the result of a survey conducted during the fall and winter of 1970-71.[3] It was restricted to farm workers and was done by personal interview. Information pertinent to this analysis includes number of hours worked during the week prior to interview, wages earned during that week, and detailed socio-economic and demographic data such as race, education level, material status, family size, and migratory status.

The one piece of information missing in the above list is data on non-employment income. This variable is somewhat troublesome, even with complete information, since many sources of such income are in some way tied to labor supply. Examples are unemployment insurance, welfare payments, and food stamps. Individuals who reported the receipt of any such items or payments must be *a priori* excluded from the analysis. The typical difficulty is that this type of income is the major source of non-employment income among low-income persons. The major remaining source of non-employment income is assets and debts, but this information was not collected in the survey under consideration. The only piece of information available is whether the family owned a house, trailer, both, or neither. Although this is not detailed information of the type we would like to have, it does permit us to draw limited inferences on income effects and is so utilized.

The Stochastic Specification

The equations of direct interest in the model are (6-10) in Table 1 where the variables are defined as follows:

Y_1 = Observed wage in week prior to interview,
Y_1^* = True wage in week prior to interview,
Y_2 = Observed housing indicator,
Y_2^* = True non-employment income,
Y_3 = Hours of labor supplied in the week prior to interview,
Y_5 = Weeks of labor supplied during 52 weeks prior to interview,
X_1 = Age,
X_2 = Education,
X_3 = Race,
X_4 = Migratory status,
X_5 = Existence of health problems,
X_6 = Located in Central Florida,
X_7 = Located in South Florida,
X_8 = Receipt of fringe benefits,
X_9 = Number of adults in interview unit,
X_{10} = Number of dependent children in interview unit.

Equation (10) reflects supply of hours in the week prior to interview as a function of the week's nonemployment income, age, number of adults in the interview unit, number of children in the interview unit, and the individual's race.

Weekly wages, Y_1^*, are assumed to be observed with error resulting from such factors as reporting bias, poor memory and the implicit imputation of weekly wages as the product of an hourly wage and hours worked (or analogously the piece rate by the number of pieces completed). Unobserved true wages are assumed to be a log-linear function of socio-economic variables as well as the location of the individual in the state [equation (6)].

Since there are essentially no non-employment income data in the date file, Y_2^* is also a non-observed variable in equation (10). As noted above, ownership of housing is observable. This is included as a polytomous variable with $Y_2 = 1$ for no housing, 2 for ownership of a trailer, 3 for ownership of a house, and 4 for ownership of both. Equations (8-9) represent the assumed relationship of Y_2 to Y_2^*. This specification assumes that the magnitude of non-employment income Y_2^* is a constant multiple of our polytomous variable Y_2, ignoring the stochastic term ε_2 for the moment.

Unobserved non-employment income is assumed to be a log-linear function of weekly wages, labor supply and life-cycle or preference variables such as age, race, education, and migratory status. The appropriate labor supply variable in this equation is annual supply, Y_5, rather than Y_3. Although it is assumed that Y_5 is endogenous, we merely recognize that the reduced form for Y_5

3 See Moses and Polopolus [5] for a more detailed discussion of the sampling procedure.

Table 1. THE LABOR SUPPLY EQUATION SYSTEM

Equation number	Equations
	Basic model
6	$Y_1^* = X_1^{\alpha_1} X_2^{\alpha_2} \exp\{\alpha_0 + \sum_{i=3}^{8} \alpha_i X_i + \mu_1\}$
7	$Y_1 = Y_1^* e^{\varepsilon_1}$
8	$Y_2^* = Y_1^{*\delta_1} Y_5^{\delta_2} X_1^{\delta_3} X_2^{\delta_4} \exp\{\delta_0 + \delta_5 X_3 + \delta_6 X_4 + \mu_2\}$
9	$Y_2 = \phi Y_2^* e^{\varepsilon_2}$
10	$Y_3 = Y_1^{*\beta_1} Y_2^{*\beta_2} X_1^{\beta_3} X_9^{\beta_4} X_{10}^{\beta_5} \exp\{\beta_0 + \beta_6 X_3 + \mu_3\}$
	Observable model
11	$Y_1 = X_1^{\alpha_1} X_2^{\alpha_2} \exp\{\alpha_0 + \sum_{i=3}^{8} \alpha_i X_i + \mu_1 + \varepsilon_1\}$
12	$Y_2 = Y_1^{\delta_1} Y_5^{\delta_2} X_1^{\delta_3} X_2^{\delta_4} \exp\{\delta_0 + \ln\phi + \delta_5 X_3 + \delta_6 X_4 + \mu_2 + \varepsilon_2 - \delta_1 \varepsilon_1\}$
13	$Y_3 = Y_1^{\beta_1} Y_2^{\beta_2} X_1^{\beta_3} X_9^{\beta_4} X_{10}^{\beta_5} \exp\{\beta_0 - \beta_2 \ln\phi + \beta_6 X_3 - \beta_1 \varepsilon_1 - \beta_2 \varepsilon_2 + \mu_3\}$

would include only the exogenous variables X_1 through X_{10} noted above.[4]

The specification of the system in terms of observable variables consists of equations (11-13) of Table 1. The system's most interesting equation is (13), the supply function for hours of work. Motivation for the log-linear specification should now be clear: the Y_2 parameter in the supply equation is the same parameter as that of the unobservable non-employment income Y_2^* in the original form, equation (10). A linear model, for example, would not permit estimation of β_2.

Although Aigner [1] estimated a model somewhat similar to the above by limited information maximum likelihood (LIML) methods, preliminary results with this technique appeared to fall in the range in which the estimator is unstable [9, pp. 529-532]. Two stage least squares (TSLS) would normally provide consistent estimates of the parameters of (13), recognizing that Y_1 and Y_2 are measured with error. Only very recently, however, have attempts been made to treat polytomous dependent variables such as Y_2 within a multiple equation system [6]. Since an alternative approach utilizing additional data is being considered for future research, this approach has not been pursued. Rather, the results reported below are TSLS estimates, but with Y_2 included as its own instrument.[5]

The Estimates

The sample has been restricted to married male family heads for the results presented in this

[4] Inclusion of a supply equation for weeks in the model is being undertaken in further research, but its treatment is beyond the scope of the present paper.

[5] The usual procedure for continuous variables would not include Y_2 as an instrument. However, exclusion of Y_2 as an instrument gave results which were rather suspicious, particularly for the coefficient of $\ln Y_2$. The estimated β_2 was -1.2398 which differs substantially from the reported estimate, and as will be pointed out below, differs even more from reported estimates based on other data sets where superior information is available for this variable. Although it is recognized we are committing an error in either case, inclusion of Y_2 as its own instrument appears to be preferable.

paper.[6] The estimated supply equation for hours during the week prior to interview is as follows:[7]

$$(14)\quad \ln Y_3 = 1.291 + \underset{(.0571)}{.4663} \ln Y_1 - \underset{(.0257)}{.0519} \ln Y_2 + \underset{(.0420)}{.0756} \ln X_1 + \underset{(.0286)}{.0535} X_3 + \underset{(.0346)}{.0556} \ln X_9 + \underset{(.0212)}{.0423} \ln X_{10}.$$

The wage variable Y_1 has been defined in terms of earnings for the entire week. The pertinent decision variable, however, is the hourly wage rate obtained by dividing earnings by number of hours per week. The equation is estimated prior to this transformation to avoid additional spurious correlation with the independent variable, since Y_3 would appear on both sides of the equation. After making this transformation the equation and parameters of interest are:

$$(15)\quad \ln Y_3 = (1/1\text{-}\beta_1)\{(\beta_0 - \beta_2 \ln o) + \beta_1 \ln(Y_1/Y_3) + \beta_2 \ln Y_2 + \beta_3 \ln X_1 + \beta_4 \ln X_9 + \beta_5 \ln X_{10} + \beta_6 X_3 + (-\beta_1 \varepsilon_1 - \beta_2 \varepsilon_2 + \mu_3)\}.$$

Thus the gross response of hours of work to a change in the hourly wage rate is $\beta_1/1\text{-}\beta_1$. Similarly, all other coefficients are divided by $(1\text{-}\beta_1)$ to obtain the proper dimensionality. The estimates for the transformed equation are:[8]

$$(16)\quad \ln Y_3 = 2.419 + \underset{(.2003)}{.8737} \ln(Y_1/Y_3) - \underset{(.0519)}{.0972} \ln Y_2 + \underset{(.0840)}{.1416} \ln X_1 + \underset{(.0591)}{.1002} X_3 + \underset{(.0658)}{.1042} \ln X_9 + \underset{(.0399)}{.0792} \ln X_{10}.$$

First, this specification clearly rejects the backward bending labor supply curve for hours of work per week. Slightly less than unit elasticity is indicated with a standard error less than one fourth the coefficient. Secondly, liesure is a normal good; a one percent increase in income is accompanied by a 0.1 percent decrease in labor supply.

The remaining variables indicate socio-economic effects on labor supply, holding wages and income constant. All these variables indicate a positive effect on labor supply after adjusting for differences in wage rates and non-employment income. Although the effect of age is not as strong as some of the others, it does indicate greater labor supply, *ceteris paribus,* the older the person. (An alternative interpretation of this result is that younger persons have a higher reservation wage.) Non-whites' labor supply schedule appears to be to the right of the whites' supply schedule. The number of adults and dependent children in the household both increase the supply of labor, *ceteris paribus.*

Substitution and Income Effects

Inferences on the substitution effect must be made with reference to the observed wage response and income effect. The observed income coefficient in equation (16) is an income elasticity defined as ${}^{n}Y_n(WL/Y_n)$ for comparability with other studies [2, p. 334]. Estimated substitution elasticities are then obtained by converting the Slutsky equation (5) to elasticity form:

$$\varepsilon^s = \frac{\partial L}{\partial W}\frac{W}{L} - \frac{WL}{Y_n}\frac{\partial L}{\partial Y_n}\frac{Y_n}{L} = \varepsilon - \frac{W\bar{L}}{Y_n}\,{}^{n}Y_n$$

where the left hand term is income-compensated wage (substitution) elasticity, ε is the observed

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[6] Previous studies have shown that partitioning the data sample is advisable in order to have a somewhat homogeneous group, and married male household heads are one of the more important groups. The restricted sample contains 811 persons.

[7] Standard errors are in parentheses below the coefficients.

[8] Approximate standard errors are obtained by the following approximation [3, p. 444]:

$$\mathrm{Var}\,\frac{\beta_k}{1-\beta_1} \simeq \left(\frac{\partial(\beta_k\,(1-\beta_1))}{\partial\beta_k}\right)^2 \mathrm{Var}\,(\beta_k) + \left(\frac{\partial(\beta_k\,(1-\beta_1))}{\partial\beta_1}\right)^2 \mathrm{Var}\,(\beta_1) + 2\,\frac{\partial(\beta_k\,(1-\beta_1))}{\partial\beta_k}\cdot\frac{\partial(\beta_k\,(1-\beta_1))}{\partial\beta_1}\,\mathrm{Cov}\,(\beta_1, \beta_k).$$

wage elasticity, and the final term is total income elasticity. Estimates of $\mathcal{E}$ and η_{Y_n} with their standard errors from equation (16) are .8737 (.2003) and —.0972 (.0519), respectively.

The missing piece of information is the ratio of $W\bar{L}$ to Y_n. Although $W\bar{L}$ is observable, the latter term is not. One way of approaching this problem is to select alternative values for the ratio and evaluate $\mathcal{E}^s$ for each of them. As will be shown, this does not drastically reduce the information content of our results. A reasonable lower bound for the ratio is five, assuming that labor earnings are at least five times non-employment income. Estimates of $\mathcal{E}^s$ are presented in Table 2 for selected values of the ratio, $W\bar{L}/Y_n$. These show that for reasonable values of the ratio $W\bar{L}/Y_n$, the income-compensated wage effects are moderately elastic.[9]

Table 2. INCOME-COMPENSATED WAGE ELASTICITIES FOR ALTERNATIVE RATIOS OF $W\bar{L}$ TO Y_n

$\frac{W\bar{L}}{Y_n}$	$\eta_{Y_n}\frac{W\bar{L}}{Y_n}$	$\hat{\mathcal{E}}^s$
2	- .1944	1.0681
5	- .4850	1.3587
10	- .9720	1.8457
20	-1.9440	2.8177
.	.	.
.	.	.
.	.	.
∞	$-\infty$	∞

The above results are somewhat different than those reported by other researchers [2, pp. 332-333]. Total income elasticities correspond closest with other studies, while substitution effects are somewhat stronger than those of other studies, typically based on the SEO data file. Of all studies reported in Cain and Watts [2, pp. 332-333], none were greater than unity and most were in the neighborhood of zero.

Some of the major differences between this study and earlier studies follow. Most previous work has been based on the SEO data file, although the CPS data, the National Longitudinal Survey data, and Census Public Use files have also been used. All these are household surveys rather than employer-based surveys. Secondly, a logarithmic form is used rather than the additive form used by most earlier studies. Third, a decision time unit of a week is used rather than a year. Fourth, as a result of a deficiency in the data, a proxy is used to measure non-employment income. Finally, there is more detail available on wages and hours than in other data sources. In particular, these variables are reported as continuous variables rather than interval values as in other data sources.

CONCLUSIONS AND IMPLICATIONS

Although emphasis has been placed on obtaining estimates of the substitution and income effects of wage rate changes, not to be overlooked are the gross labor supply estimates of response to wage changes. The estimated labor supply function has a positive slope with a coefficient more than four times its standard error. While it is true that the functional specification does not permit the sign of the slope to change for alternative wages, there is little indication that this would happen were this constraint relaxed. The important point to recognize is that our results imply a positive labor supply response to wage rates for the average farm worker, and it is this average farm worker upon whom we should be basing our policy recommendations.

A not infrequent conjecture with respect to farm workers is that they have an income target for which they strive. Assuming that they have met this under the prevailing wage, the implication of the income target hypothesis is that increases in wage rate will lead to a reduction in number of hours worked: the worker has met his target and at a higher wage he can meet it sooner. The above results do not support this conjecture, alternatively labeled as a backward bending labor supply curve. Rather, estimates imply than an increase in wage rate would be accompanied by a nearly equally proportionate increase in labor supply since the elasticity is .87.

Information on income and substitution effects provides a starting point for more detailed analyses of public policy programs such as income maintenance plans and unemployment insurance protection which directly alter the individual's market trade-off between goods and leisure. The simplest type of income maintenance program would involve an income transfer to

[9] One could view the ratio of $W\bar{L}/Y_n$ as the inverse of the proportion which accrued earnings from housing are of wage earnings. If this were 20 percent, the ratio would be five. When viewed in this way, very large values of $W\bar{L}/Y_n$ become rather unrealistic as do very small values.

those individuals who, for one reason or another, do not have the income earning potential to obtain a "minimal" income level. In this case, only the income effect would be operative. Estimates of the income effect imply a moderate decline in labor supply by participants in this type of program. The more common proposal, for example H.R.1 (June 1971), is typically much more involved, imposing a negative tax on earnings of participants. For the purposes of analysis, these programs can alternatively be characterized as involving a lump sum transfer with earnings taxed away at a positive rate until the initial transfer is depleted. This adjustment involves both an income effect and a substitution effect. The overall adjustment would be to reduce the labor supply of participants, since the income and substitution effects would both imply a reduction in the number of hours worked.

An alternative public policy which has received some consideration is a wage subsidy program. The government would effectively increase the wage rate of working poor people by subsidizing it. Although both the income and substitution effects would be operating, their effects would be in opposing directions. Estimates presented in this paper indicate that the substitution effect would dominate. Thus, to the extent that no adjustment in the wage rate is paid by an employer, such a policy would lead to an increase in hours worked.

Detailed analyses of such programs typically require extensive simulation efforts. Policy variables of interest which can be estimated by such analyses would be the aggregate magnitude of labor supply change, participation level in the program, distribution of benefits in the program and cost of the program. Research is currently underway applying some results to the impact of extending unemployment insurance protection to agricultural workers. This involves not only a simulation of the program but also additional estimation of labor supply functions for alternative time periods.

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