An Econometric Investigation of the Market for Hired Labor
In Agriculture*

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Dimensions of the Study

The purpose of this study is to investigate the market for hired labor

faced by the agricultural industry. The basic tools in the analysis are

demand and supply relations for the hired labor resource. These demand and

supply relations are estimated by using time series data generated by the

economy in the period 1929-1957. The approach is aggregative[1] in nature,

and assumes that it is reasonable to consider agriculture as facing a labor

market that can be described by one demand and supply curve.

The basic model assumes the simultaneous determination of hired employ-

ment and agricultural wages by the interaction of demand and supply relations.

Hence the study involves an analysis of a subsector of the economy, using

two structural equations as a complete model. Wage rate and employment in

the industry are assumed to be mutually or endogenously determined, subject

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[1]It is recognized that the degree of aggregation involved is rather
herioc. Farm labor markets are scattered from San Diego to Maine; hired
farm employees range from graduates of Iowa State University to illiterate
Mexican pea pickers. But for some purposes, such as the analysis of supply
response for the total agriculture industry, information concerning the aggre-
gate demand and supply curves for the factors of production is useful. Des-
pite the fact that high levels of aggregation involve problems, useful in-
sights can be gained, especially when data limitations preclude further dis-
aggregation. Whether the market is sufficiently homogenous to prevent seri-
ous specification bias is of course ultimately an empirical question.

to the impact of various exogenous variables. A distributed lag model is introduced into both the demand and the supply relation in order to obtain long-run and short-run elasticities. Theil-Basman estimating procedures are applied to this basic model in order to allow for the constraints implied by one equation when estimating the other. Ordinary least squares estimating procedures are also applied to the structural equations in order to gain additional insights. As a final part of the study, several implications of the structural relationships are examined.

Some Background

The number of persons engaged in farming has been subject to large secular movements over time. In 1870 an estimated 6.8 million persons worked on farms as operators, hired hands, or unpaid family workers. Thereafter, the number of persons engaged in agriculture increased steadily, reaching 11.6 million in 1910,[2] and a final peak level around 1917. Since that time, employment in agriculture has fallen almost steadily.

A major portion of this decline has taken place since 1929. Using Department of Agriculture estimates of employment, the total labor force in agriculture declined from an average level of 12,691,000[3] in 1929 to 7,384,000[4] in 1959. At the same time the index of the composite wage rate, which provides a summary measure of the various forms of wage payments to hired labor in agriculture, increased from a level of 187[5] in 1929 to a level of 614[6] in 1959 (1910-14 = 100). During the depths of the depression the index of wage rates fell as low as 89.

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[2]/Data are taken from Historical Statistics of the U.S., Bureau of the Census, 1949, Table DI-10, p. 63.

[3]/Farm Labor, Agricultural Marketing Service, U. S. Department of Agriculture, October, 1953.

[4]/Ibid., February, 1961

[5]/Ibid., December 11, 1950

[6]/Ibid., February, 1961

Interpreting this body of data by the estimation of demand and supply
relations for the labor resource will permit a better understanding of the
economic forces causing this sizeable transfer of resources. This, in turn,
will provide insights into what to expect in the future, and permit the
development of more socially desirable policy measures.

Many studies have been made of this important migration process. From
an aggregate standpoint, most of these studies have concentrated either on
the total agricultural labor force, or on the farm population. This study
attempts to delve deeper into the total adjustment process by analyzing
the hired and family components of the labor force separately.[7]

The Conceptual Model

This research concerns itself with the numbers of people employed in
agriculture and the wages they earn. It does not consider changes in the
quality of the labor resource, nor changes in the hours worked by the indivi-
dual. This is a valid approach only insofar as the forces determining these
various dimensions of the labor input are largely independent of each other.
To the extent that these conditions are not fulfilled, the structural para-
meters obtained may be biased.

The supply of labor offered to an industry. Theory suggests that the
supply curve relating the quantity of labor supplied to an industry and its
price will in general be positively sloped. The positive slope arises from
differences in tastes for various occupations by members of the labor force,
differences in abilities to perform the various tasks, the degree of geo-
graphic mobility by members of the labor force, and the proximity and size
of the available labor pool.

[7]The proportion that each of the components make up of the total labor
force has remained relatively stable over time, with hired labor making up
approximately 25%, operator labor 55%, and unpaid family labor approximately
20%.

In a world of perfect mobility, uniform tastes for occupations, or--
what is the same thing--no tastes for occupations, and equal abilities by
everyone, the labor supply schedule to an industry would be approximately
perfectly elastic. A slight rise in the wage rate within an industry would
attract an infinite number of workers to the industry. To the extent that
these conditions are not fulfilled the supply schedule will slope positively.
Increasingly higher relative wage rates will be required to induce workers
to supply their labor services to a specific industry.[8]

The variables to be included in the supply equation include: (1) a
measure of hired employment, which will be the dependent variable, (2) a
measure of the income to be earned in agriculture, (3) a measure of the
income earned in non-agricultural employment, (4) the amount of unemployment
in the economy to reflect a separate dimension of the income alternatives,
and (5) the size of the civilian labor force, to abstract from the entry and
exit dimension of the supply of labor problem.

The demand for labor by an industry. Marginal productivity theory is
useful as a tool for organizing the considerations determining the demand
for a factor of production.

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[8] The theory can be expressed in two forms. In one interpretation
the relation can be developed by dividing the economy into two industries
and expressing the relative quantity supplied to one of the industries as
a function of the relative wage rate between the two industries. This method
is not perfectly general and implies that the relative quantity of labor
supplied to an industry would be independent of the level of wages. It is
not obvious that this will be the case.

A second and more general method is to express the absolute quantity of
labor supplied to an industry as a function of the absolute wage in the in-
dustry. In this case the wage in the alternative industry and the size of the
total labor force are included in the ceteris paribus conditions of the supply
curve.

In this research the absolute wage model is used because (1) it is more
general, and hence provides more information, (2) it is consistent with the
simultaneous determination of wages and employment in agriculture postulated,
and (3) the data series available to represent the income concepts are not
comparable, strictly speaking, and to enter them in the model as a ratio
would be less meaningful.

Two models can be developed that are consistent with this theory. The value of the marginal product is the demand price for a productive service if the <u>quantities</u> of the other productive services are held constant. Empirical knowledge of the production function or an equilibrium assumption would permit the estimation of the demand relation for labor. Important ceteris paribus conditions would then be the price of product, the quantities of other inputs, and technology.

On the other hand, demand curves usually refer to demand prices when the <u>prices</u> of other productive services are held constant. This allows the firm to make adjustments in the quantities of other inputs as the price of labor changes. In general this demand curve will be more elastic than the curve of the value of marginal product. Important ceteris paribus conditions for this interpretation are price of product, <u>price</u> of other productive services, and technology. The second model was chosen for this research[9] because output and the level of other inputs are determined more or less simultaneously with the level of labor input, whereas prices of products and prices of other inputs can be considered exogneous and not affected, in the short run, by the decisions of the entrepreneur.[10]

Variables in the demand equation[11] include (1) a measure of hired employment as the dependent variable, (2) a measure of wage rates or the price

[9]For a similar procedure, see Griliches, Zvi, "The Demand for Fertilizer: An Economic Interpretation of a Technical Change," <u>Journal of Farm Economics</u>, Vol. XL, No. 3, p. 596.

[10]This is, of course, probably true at the firm level, but is less likely on the aggregate level. It is, to a degree, inconsistent with the decision to consider the price and quantity of labor as being endogenously determined. However, whether a variable is used as exogenous or endogenous is to a degree arbitrary, depending in part on the scope of the model. For purposes of analyzing the demand for hired labor, agricultural prices and prices of other inputs are relatively exogenous to hired employment and wage rates, thus permitting meaningful results to be obtained.

[11]This study assumes that the income earned and the level of employment of each of the sub-aggregates of the labor force are determined relatively

of labor in agriculture, (3) an index of the prices of agricultural products to reflect derived demand considerations, (4) an index of the prices of other inputs, and (5) a measure of technology.

Some Data Problems[12]

The measure of agricultural employment. Currently available estimates of employment in agriculture are dominated by the seasonality of agricultural production. The seasonality of production results in seasonal variations in labor use, with employment in the slack seasons often being only 50 percent as much as it is in the peak seasons. Consequently, the employment estimates available do not measure directly the number of different people employed, but rather a year-equivalent concept.[13]

This problem does not necessarily detract from the study, however. In an industry with as much seasonality of employment as agriculture, perhaps the more meaningful concept of employment is year-equivalents. Certainly, in most questions dealing with the aggregate supply response of the agricultural industry, this is the more useful measure of the labor input. And

independent of each other. A more realistic assumption might be that the supply of unpaid family labor is an important determinant of the demand for hired labor. This possibility was not examined in this study because the unpaid family labor portion of the labor force is measured so poorly. This problem is being examined in further research by the author, as part of a more comprehensive analysis of the factor markets.

[12] A more complete critique of the data concepts used and the degree to which they correspond to the theoretical concepts are discussed in detail in the appendix of the author's doctoral dissertation "An Econometric Investigation of the Market for Hired Labor in Agriculture," unpublished, University of Chicago. Since some of these concepts are crucial in the analysis which follows they are discussed briefly at this time.

[13] The procedure used in constructing the data series is to estimate the employment once a month on the basis of a sample, and to construct the annual estimate by taking a simple average of these monthly estimates. What is measured as annual employment then, is not numbers of people employed in agriculture on a full-time basis, but rather the year-equivalents of labor employed in agriculture.

on the demand side, it is year-equivalents that the industry demands, not
full-time employees. For this reason, no attempt has been made to adjust
the data. It is importnat, however, to recognize what the employment con-
cept is measuring when interpreting the results.

Unemployment as a supply shifter. Unemployment is included in the
supply model as a correction for the non-farm income concept. Strictly
speaking, non-farm income does not measure the true off-farm income alter-
natives, but instead represents the off-farm alternatives given that jobs
are available. Non-farm opportunity costs for farm labor go to zero as the
level of unemployment in the economy increases.

Two possibilities are available for including this concept in the model.
The non-farm income series can be synthesized in such a manner as to include
the possibilities of unemployment. This can be done by considering all people
in the labor force when constructing the average nonfarm income concept, and
weighting the unemployed with zero incomes and the employed with their aver-
age income. This allows the non-farm income concept to represent both f ac-
tors and provides an implicit correction for the possibility of not being
employed. Alternatively, a separate variable for unemployment can be intro-
duced into the model. Both procedures were followed in the course of the
study, though it was not possible to isolate the separate effects of unem-
ployment, except indirectly. The results reported here include only those
using the "corrected" nonfarm income concept, which implicitly accounts for
the possibility of being employed.

The income concepts. It would be desirable to have comparable concepts
measuring the income alternatives. Since the model is attempting to explain
annual employment, the more appropriate concept would be in terms of annual
income. Two considerations argue against using an annual income concept in
agriculture. First, since such a large portion of the hired labor force is

hired on a short term basis an annual income concept is not meaningful.
This is especially true on the demand side. Second, the available wage
rate concept is more accurately measured than the expenditure on hired
labor series from which the annual concept would be developed.[14] For these
reasons a wage rate concept is used to reflect the income or price of labor
in agriculture.

Lack of data precludes using a comparable concept to represent nonfarm
income opportunities. There is no comprehensive measure of wage rates that
provides a sufficiently broad industry coverage, nor is there sufficient
information to synthesize one. Available data on total compensation to
employees does permit the construction of an average annual income measure
for non-farm employment, however, and this if the concept used.[15]

Statistical Models and Estimation Procedures

Estimation techniques. The use of a two-equation model is based on the
assumption that the employment of hired labor and agricultural wage rate
are mutually determined or endogenous, and affected by various exogeneous
variables, but do not in turn affect those exogenous variables.[16] If this
assumption is valid, ordinary least squares as applied directly to the
structural equations is not appropriate and will give rise to inconsistency
bias. An alternative estimation technique is required that accounts for the
simultaneous determination of wage rate and employment. For this purpose

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[14]The expenditures on hired labor series is bench-marked on census
years and interpolated on the basis of the wage rate indices.

[15]Space limitations prevent a discussion of how this series is con-
structed. The data series used in estimation, and the method of construc-
tion for those that are synthesized, are available in mimeographed form
from the author upon request.

[16]The choice of variables in the demand and supply equations was in
part conditioned by the choice of a two equation model. For instance, in
the demand equation, price of other inputs was chosen rather than quantities
of inputs because they can more realistically be considered exogenous.

Theil-Basmann[17] procedures have been employed. Ordinary least squares
procedures were also applied to the structural supply and demand equations
for purposes of additional analysis.

Obtaining Long Run and Short Run Elasticities. Recently, Nerlove has
argued that statistical estimation of long-run elasticities of supply or
demand logically precedes the estimation of short run elasticities.[18]
It is in keeping with this hypothesis that attempts are made to obtain long-
run elasticities in this study. The specific technique used is based on
the concept of a distributed lag and follows the approach originally pro-
posed by Koyck,[19] but recently developed by Nerlove and others. The
approach and its limitations have been rather thoroughly discussed else-
where, and will not be elaborated here.[20] When quantity demanded or

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[17]See Theil, H., "Estimation and Simultaneous Correlation in Complete
Equation Systems," Central Plan Bureau, the Hague, June 23, 1953 (mimeograph-
ed) and R. L. Basmann, "A Generalized Classical Method of Linear Estimation
of Coefficients in a Structural Equation," Econometrice, Vol. XXV-1, January
1957, pp. 77-84.

[18]Nerlove, Marc, and William Addison, "Statistical Estimation of Long-
Run Elasticities of Supply and Demand," Journal of Farm Economics, Vol. 40,
Nov. 1958, pp. 861-880.

[19]Koyck, Distributed Lags and Investment Analysis, Amsterdam: North
Holland Publishing Company, 1954.

[20]The model can be illustrated by considering the demand equation for
hired labor developed later. A long-run labor demand function is postulated
which may be written:

$$\overline{X}_{8_t} = aX_{7_t} + bX_{2_t} + cX_{6_t} + d$$

where $\overline{X}_{8_t}$ = the long-run or equilibrium quantity demanded, X_{7_t} = the

agricultural wage rate, X_{2_t} = the "real" price of farm products, and X_{6_t} =

an index of technology.

The long-run or equilibrium quantity demanded cannot be observed because
the other variables are continually changing. Therefore, this equation cannot
be estimated directly.

Let X_{8_t} be the current quantity demanded. In the absence of changes

in the independent variables upon which demand depends, it is assumed that
the current quantity demanded would change in proportion to the difference

supplied is the dependent variables the technique involves adding the dependent variable lagged one period as an additional independent variable in the original demand or supply equation. The parameter estimate of this variable implies a coefficient of adjustment which expresses the relationship between short run and long run elasticities.

A Statistical Model and Identification Properties. Identification properties restrict the choice of estimation procedures since not all procedures utilize over-identifying constraints. Incorporating the adjustment equation into each structural equation on the distributed lag considerations leads to a model of the following form:

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between the long-run equilibrium quantity and the current quantity. This assumption may be expressed by the following difference equation:

$$X_{8t} - X_{8t-1} = \sqrt{}\left[\bar{\bar{X}}_{8t} - X_{8t-1}\right] \quad 0 < \sqrt{} < 1$$

where the variables are identified as earlier and $\sqrt{}$ is a coefficient of adjustment, showing what proportion of the disequilibria is removed in one time period.

Substitution of this adjustment equation into the long-run or equilibrium demand equation leads to the following estimating equation:

$$X_{8t} = a\sqrt{}X_{7t} + b\sqrt{}X_{2t} + c\sqrt{}X_{6t} + (1 - \sqrt{})X_{8t-1} + d\sqrt{}$$

estimated in the form:

$$X_{8t} = \pi_1 X_{7t} + \pi_2 X_{2t} + \pi_3 X_{6t} + \pi_4 X_{8t-1} + \pi_5$$

This equation is not any sort of a demand function but merely a relationship among observable variables. It is useful because it is possible to derive estimates of the parameters in the long-run equation from its parameter estimates.

The coefficient of adjustment, $\sqrt{}$, can be obtained by substracting π_4 from one. Dividing the other parameter estimates of the estimating equation in turn by $\sqrt{}$ leads to estimates of the parameters of the long-run or equilibrium equation. These can then be used to compute the long-run elasticities. Short-run elasticities are obtained from the coefficients of the estimating equation. The coefficient of adjustment determines the relation among the short run elasticities and the long-run elasticities. Similar considerations apply when dealing with the supply equation.

This model assumes, rather arbitrarily, that prices adjust immediately to changed conditions, while the quantity variable is adjusted with a lag. The reasonableness of this assumption must be evaluated in the individual instance. In the case of agricultural labor, the historical record indicates that the assumption is not unrealistic.

S: $X_8 = \alpha_1 \gamma_1 + \beta_1 \gamma_1 X_7 + \gamma \gamma_1 X_{10} + (1 - \gamma_1)X_4 + \eta \gamma_1 X_5 + \mu_1$

D: $X_5 = \alpha_2 \gamma_2 + \beta_2 \gamma_2 X_7 + e \gamma_2 X_2 + (1 - \gamma_2)X_4 + \phi \gamma_2 X_6 + \mu_2$

where: X_8 = hired employment in agriculture, USDA estimate

X_7 = index of composite wage rate in agriculture, deflated by the consumer price index[21]

X_{10}= "corrected" nonfarm income, deflated by the consumer price index

X_2 = index of prices received by farmers, all products, deflated by index of prices paid by farmers for items used in production, excluding labor

X_4 = X_8 lagged one period

X_5 = size of the civilian labor force

X_6 = an index of technology developed by Ruttan.

Greek letters refer to parameters in the long-run equation, and γ_1 and γ_2 are the coefficients of adjustment for the supply and demand curves respectively.

In developing this model deflation procedures were followed as much as possible in order to conserve on degrees of freedom and reduce the collinearity. Hence agricultural wage and nonfarm income were deflated by the consumer price index rather than entering the latter as a separate variable. In addition, prices received by farmers and prices paid for items used in production except labor were taken as a ratio, producing a "real" farm prices variable. This is an economically meaningful concept in view of the demand for hired labor being a derived demand.

These equations are estimated in the forms:[22]

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[21]The consumer price index is used rather than the Index of Prices Paid for Items used in Living by Farmers, since the latter is not, strictly speaking, a cost of living index. It is not based on a continuously maintained market basket of goods.

[22]The signs of the coefficients, based on a priori considerations, are expected to be: $b_1 > 0$, $g < 0$, $r_1 > 0$, $m > 0$; $b_2 < 0$, $c > 0$, $r_1 > 0$, $p \gtrless 0$. It is not possible to utilize theory in placing a priori constraints on the coefficient of technology due to the limited scope of the model. A more complete model which accounted for such factors as the level of technology in the nonfarm sector would permit the placing of a priori constraints.

S: $X_8 = a_1 + b_1 X_7 + gX_{10} + r_1 X_4 + mX_5 + u_1$

D: $X_8 = a_2 + b_2 X_7 + cX_2 + r_2 X_4 + pX_6 + u_2$

where for instance $a_1 = \alpha_1 \gamma_1$ and $b_1 = \beta_1 \gamma_1$. Both equations are assumed to be linear in either the transformed or observed variables and in the parameters. All variables are in terms of absolute numbers or indices of absolute numbers.

Utilizing only a priori information about the model, the appropriate criterion is the order condition of identification, defined in terms of the exclusion from an equation of variables that appear in the system. On this basis both equations are over-identified, with each having one over-identifying constraint. This is one of the motivations for using Theil-Basmann estimating procedures.

Statistical Results - Simultaneous Equations

Three models will be investigated.[23/] Models I and II, based on the distributed lag considerations, are dynamic in nature, and permit the estimation of both long-run and short-run elasticities. Model II differs from Model I in that the variable with a coefficient not significantly different from zero, technology, is dropped. Model III takes the more traditional static approach, and attempts to estimate only the short-run elasticities. Both the static and the dynamic approaches give economically meaningful results. (See Table 1.)

Notice that a trend variable is introduced into both equations as a partial test for specification bias in the coefficient of the lagged vari-

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[23/]Several experiments were made with the model in the course of the study, and these are reported and discussed in the thesis. Their main objective was to isolate the separate effects of unemployment on the agricultural labor market. It was not possible to obtain a significant coefficient for unemployment entered separately, and in addition, it was difficult to identify the coefficient for agricultural wage in the supply equation in models of that form.

able. There are strong reasons for suspecting that the coefficient of

adjustment are subject to a greater extent than other parameters to speci-

fication bias, or the omission of relevant variables. This was pointed out

by Brandow,[24] Halvorson,[25] and Griliches,[26] and recognized by Nerlove.[27]

The introduction of the lagged dependent variable into the regression is

a very useful device to take into account the empirical fact that economic

variables are serially correlated. Its use as an additional independent

variable introduces the fact of serial correlation explicitly into the model.

But it may be quite wrong to attribute all of the serial correlation to the

adjustment mechanism. Some of it may be due to the serial correlation in

other variables that are left out. If this is the case, the adjustment

coefficient will be underestimated, and some of the sluggishness in the omit-

ted variables will be attributed to people's slowness to react to the included

variables. Introducing the trend variables will pick up the effects of those

omitted variables that are correlated with time, and eliminate at least that

part of the specification bias.

In Model I, the dynamic model, the sign of the coefficients are consis-

tent with a priori expectations and the parameter estimates are significant[28]

[24]Brandow, G. E., "A Note on the Nerlove Estimate of Supply Elastic-ity", Journal of Farm Economics, Vol. 40, Aug. 1958, pp. 719-22.

[25]Halvorson, Harlow W., "The Response of Milk Production to Price," Journal of Farm Economics, Vol. 40, Dec. 1958, pp. 1101-13.

[26]Griliches, Zvi, "Distributed Lags, Disaggregation, and Regional Demand Functions for Fertilizer," Journal of Farm Economics, Vol. 41, Feb. 1959, pp. 90-102.

[27]Nerlove, Marc, "On the Nerlove Estimate of Supply Elasticity: A Reply," Journal of Farm Economics, Vol. 40, Aug. 1958, pp. 719-28; and "On the Estimation of Long-Run Elasticities: A Reply," Journal of Farm Economics Vol. 40, Aug. 1959, pp. 632-40.

[28]Meinken, in an early discussion of the distributed lag model, pointed out that high R^2's should not be taken too seriously. If time series data are being used in a correlation study and if the dependent variable is corre-

Table 1   Simultaneous Equations Model -- "Corrected" Nonfarm Income

<table>
<tr><td rowspan="3">Model I</td><td>

S: $X_8 = -1330.22 + \underset{(.5668)}{1.8818X_7'} - \underset{(.1237)}{.3547X_{10}} + \underset{(.1254)}{.6792X_4} + \underset{(.1080)}{.5311X_5} - \underset{(12.76)}{45.023X_9}$

$R^2 = .9844$ $d' = 2.23$
</td></tr>
<tr><td>

D: $X_8 = \;\;\;964.64 - \underset{(.5411)}{.9061X_7'} + \underset{(2.1451)}{4.0363X_2} + \underset{(.1376)}{.7027X_4} - \underset{(2.5521)}{2.5813X_6} + \underset{(8.724)}{.1930X_9}$

$R^2 = .9698$ $d' = 1.83$
</td></tr>
<tr><td>

D: $X_8 = \;\;\;969.91 - \underset{(.4599)}{.9002X_7'} + \underset{(1.6547)}{4.0071X_2} + \underset{(.1083)}{.7009X_4} - \underset{(2.2732)}{2.5578X_6}$

$R^2 = .9698$ $d' = 1.82$
</td></tr>
<tr><td rowspan="3">Model II</td><td>

S: $X_8 = -1345.44 + \underset{(.5878)}{1.9135X_7''} - \underset{(.1283)}{.3623X_{10}} + \underset{(.1283)}{.6817X_4} + \underset{(.1147)}{.5336X_5} - \underset{(12.8406)}{44.8946X_9}$

$R^2 = .9842$ $d' = 2.10$
</td></tr>
<tr><td>

D: $X_8 = \;\;\;546.83 - \underset{(1.6090)}{1.3463X_7''} + \underset{(6.2316)}{4.8142X_2} + \underset{(.4065)}{.7501X_4} + \underset{(24.8134)}{1.7643X_9}$

$R^2 = .9725$ $d' = 1.73$
</td></tr>
<tr><td>

D: $X_8 = \;\;\;630.27 - \underset{(.3852)}{1.2735X_7''} + \underset{(1.5200)}{4.5404X_2} + \underset{(.2302)}{.7289X_4}$

$R^2 = .9724$ $d' = 1.70$
</td></tr>
</table>

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Table 1(Continued). Simultaneous Equations Estimates of the Structural Relationships.

Model III	S: $X_8 = -639.3638 + 1.400X_7''' - .1848X_{10} + \quad\quad +.8176X_5 - 102.4923X_9$ $\quad\quad\quad\quad\quad (.4960) \quad\quad (.1220) \quad\quad\quad\quad\quad (.1472) \quad (12.1582)$ $R = .9689 \quad\quad\quad\quad\quad d' = 0.82**$ D: $X_8 = 3611.2 - .6988X_7''' + 1.7846X_2 \quad\quad - 4.3427X_6 - 30.3068X_9$ $\quad\quad\quad\quad\quad\quad (.8215) \quad\quad (3.219 \quad\quad\quad\quad (3.732) \quad (10.92)$ $R^2 = .9316 \quad\quad\quad\quad\quad d' = .74**$ D: $X_8 = 3912.18 \quad -2.3513X_7''' + 8.4728X_2 - 10.7593X_6$ $\quad\quad\quad\quad\quad\quad\quad (.3301) \quad\quad (3.085) \quad (2.849)$ $R^2 = .9080 \quad\quad\quad\quad\quad d' = .93**$

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Notes: 1. d' is the value of the Durbin-Watson statistic for serial correlation in the calculated residuals
2. * Denotes that test for serial correlation in calculated residuals is inclusive.
3. ** Denotes that calculated residuals are positively serially correlated.
4. Primes on X_7 indicate that predicted value from first round estimation is used rather than observed values.

Variable identification:

X_8 = hired employment in agriculture, USDA estimate
X_7 = index of composite wage rate in agriculture, USDA, deflated by consumer price index
X_2 = index of prices received by farmers, all products, deflated by index of prices paid by farmers for items used in production, excluding labor
X_4 = X_8 lagged one period
X_5 = civilian labor force
X_6 = Ruttan's index of technology -- a revision of index published in graphic form
X_9 = linear time trend
X_{10} = "corrected" nonfarm income

at usually accepted levels, with the exception of the coefficient for technology. However, the standard error of this coefficient is smaller than the parameter estimate. The coefficient of the trend variable in the demand equation is not significantly different from zero and consequently is dropped. The result is to obtain 5% levels of significance or better for the coefficients of all variables except technology in the demand equation. All parameter estimates in the supply equation are significant at the 1% level or better.

In examining the distributed lag model, note that the coefficient of the lagged variable, the operational variable for the distributed lag hypothesis is highly significant. An additional test of the model is to determine whether γ, the coefficient of adjustment, is significantly different from zero. This test can be made by testing whether the coefficient of the lagged variable, $1 - \gamma$, is significantly different from one. In both the demand and supply equations of Model I the coefficients of the lagged variable are significantly different from one at the 5% level.

Note also that the coefficient of the trend variable is highly significant in the supply equation. This variable apparently is necessary to remove

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lated with time, then including the dependent variable lagged as an independent variable will automatically result in high R values. (See Meinken, K. W., "Discussion: Distributed Lags and the Measurement of Supply and Demand Elasticities," Journal of Farm Economics. Vol. 40, May 1958, pp. 311-313).

Griliches also recognized this in a study using the model and suggested that the more relevant criterion was the first order partial correlation coefficients or the "significance" of the individual variables. (See Griliches, Zvi, "The Demand for Fertilizer: An Economic Interpretation of a Technical Change," Journal of Farm Economics, Vol. 40, Aug. 1958, pp. 591-606.)

Consequently, in evaluating the equations major emphasis has been placed on the tests of significance for the individual variables rather than the success of the equation in explaining variations in the dependent variable. The partial correlation coefficient could be considered but it is difficult to interpret them when using Theil-Basmann estimating procedures. Strictly speaking, the "significance" of the individual variables is closely related to the partials, since they are based on the same information. In the context of simultaneous equations, however, the concept of "significance" has more intuitive appeal than the concept of partial correlation.

some of the specification bias that arises from incomplete model specification. Though this model was not estimated with the trend variable omitted, in earlier experiments with the model, when the trend variable was not present, the coefficient of the lagged variable was larger, implying a lower coefficient of adjustment.

Using the Durbin-Watson statistic as a criterion, the null hypothesis of no serial correlation in the calculated residuals is not rejected at the 5% level for either the demand or supply relation. However, this test must be interpreted with care. The absence of serial correlation in the residuals usually indicates a properly specified model, since it is evidence that there is nothing systematic remaining in the residuals. The problem is especially important in the present context because the presence of serial correlation in the residuals when a lagged dependent variable is present leads to a biased estimate of the parameter for that variable. Naively, a failure to reject the null hypothesis of no serial correlation in the calculated residuals would provide evidence that this coefficient is unbiased.

Previous empirical work with the model, and a theoretical discussion by Griliches,[29] indicate that the coefficient of the lagged variable can be subject to specification bias in spite of rejecting the null hypothesis of no serial correlation in the residuals.[30] In essence, introducing the fact of serial correlation into the model explicitly may remove the serial correlation in the residuals for the wrong reason. Whether the serial correlation is being removed from the residuals for the correct reason depends both on whether the distributed lag is a correct hypothesis and whether the rest of

[29]Griliches, Zvi, "A Note on Serial Correlation Bias in Estimates of Distributed Lags", Econometrica, forthcoming.

[30]This was the motivation behind the original introduction of the trend variable in each equation.

the model is correctly specified. This can be answered only in part by criteria arising from statistical estimation.

In Model II technology, X_6, is omitted from the demand equation as a test of the model. In doing this the trend variables is again included in the demand equation, this time as an alternative to the technology variable previously used. The coefficient of the trend variables is again not significantly different from zero in the demand equation and as a consequence is omitted again. Its presence gives rise to collinearity problems which preclude obtaining stable parameter estimates for the other variables.

When omitting technology from the demand equation, the coefficients of the supply equation are quite stable. In the demand equation there are some slight changes in coefficients, all parameter estimates increasing slightly in absolute magnitude. The Durbin-Watson test statistic declines when technology is omitted, but not sufficiently to reject the null hypothesis of no serial correlation in the calculated residuals. The more desirable model is, however, considered to be Model I, with technology in the demand equation. The theory suggests that it be included, and though its coefficient is not significantly different from zero at usually accepted levels, the standard error of the coefficient is smaller than the absolute magnitude of the coefficient.[31]

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[31]/Lack of significance for this variable may reflect more the inadequacy of the data series used to measure it than the lack of an underlying relationship. Ruttan's index of technology is barely adequate as a measure of the year to year change in technology. In the short run it is quite sensitive to weather conditions and price movements. Taken literally the index would indicate a recession of the level of technology for many years. This is hardly tenable given the usual interpretation of technological change. Attempts to smooth the series to eliminate these short run fluctuations by using a moving average produced collinearity and unstable parameter estimates. Though inadequate in many respects for the purpose put to in this study, Ruttan's index has more intuitive appeal than introducing the usual time trend to represent technology, and in this model actually performs better than the trend variable.

In Model III, estimated in a static framework,[32] it is expected that
the estimated coefficients will change in absolute magnitude. The short
run and long run adjustments are no longer being separated, but rather
measured as a combined effect. The change turns out to be larger in the
demand equation than in the supply equation, perhaps partly due to the
change in the significance of "corrected" nonfarm income in the supply equa-
tion.

In both equations of Model III a trend variable is added as an alterna-
tive to the distributed lag hypothesis.[33] This causes problems in the
demand equation. In the absence of the lagged dependent variable, trend
turns out to be the only variable with a significant coefficient. Since
the trend variable had not been relevant in the demand equation of any of
the other models estimated, and since it has no justification in economic
theory, the demand equation was estimated with trend omitted. The coeffi-
cients of the remaining variables are highly significant, including that
for technology. Presumably the high intercorrelation of trend with the
technology variable resulted in unstable parameter estimates.

In the supply equation of Model III, the coefficients of all variables
agree in sign with a priori expectations, and all except that for "corrected"
nonfarm income are highly significant. The coefficient for this variable
is significant at the 10% level. Hence, meaningful results are possible

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[32]Model III was estimated in part to determine whether meaningful results
could be obtained without the aid of the lagged dependent variable. An inter-
mediate hypothesis was examined in which the distributed lag model was assumed
to hold only in the demand equation, with trend alone explaining the long
secular change in the quantity supplied. This model did not yield any addi-
tional insights and the coefficients in the supply equation, though consis-
tent in sign with Model I, were not significantly different from zero.

[33]Strictly speaking, then, Model III is not a static model. However,
the trend variable can be looked at, not as a specific dynamic assumption,
but rather as an attempt to pick up the effects of omitted variables that
are highly correlated with time.

for both equations without the "aid" of the lagged dependent variable.

In both the demand and supply equations of Model III the null hypothesis of no serial correlation in the residuals is rejected. The Durbin-Watson test indicates that the calculated residuals of both relations are positively serially correlated, reflecting the presence of systematic relationships in the unexplained residuals. The ability of the distributed lag model in Model I to remove this serial correlation from the calculated residuals provides limited support for the distributed lag model as a maintained hypothesis.

In concluding this section both Model I, a dynamic model that will produce both long run and short run elasticities, and Model III, a static model that does not separate long run and short run elasticities, are acceptable models by the usual statistical criteria.[34] In each model the price or agricultural wage variable is highly significant. And each model has only one variable with a coefficient not statistically significant at usually accepted levels, though in each case the parameter estimate is larger than its respective standard error. Model I has the advantage of yielding more information than Model III, and of passing the test for serial correlation in the calculated residuals.

Single Equation Models

Though statistical estimates of the single equation models are not presented, they did yield insights that have economic implications. Ordinary least squares consistently failed to obtain a parameter estimate for agricultural wage in the supply equation that was significantly different from zero. This is evidence of failure to identify the supply relation by

[34]/In each case reference is made to those versions of the models which omit the trend variable from the demand equation.

using a single equation model. The demand equation, however, possessed similar degrees of significance for the parameter estimates, and in addition the parameter estimates agreed closely in absolute magnitude to those obtained in a simultaneous equations context.

These findings suggest that historically the demand relation has been more stable than the supply relation. The fact that observed wages and employment have been generated by a supply function that has shifted across a relatively stable[35] demand function permits the identification of the price or wage parameter using a single equation model. But in order to identify the price or wage parameter in the supply equation, account must be taken of the constraints implied by the demand equation. Hence, simultaneous equation procedures are appropriate to obtain parameter estimates that meet the usual statistical criteria.

Structural Elasticities

Elasticities were computed from both Model I and III, and in the case of the demand equation, from the ordinary least squares estimates. The elasticities are computed at two points on the functions, one at the means and another at the more recent 1957 levels. Though the elasticities evaluated at the mean are more reliable in a statistical sense,[36] they are less meaningful in an economic sense, as economic change pushes the economy to new positions on the structural relations. This is particularly important in view of the secular decline in employment and rise in real wages in agriculture.

[35]This does not imply that the demand function has not shifted. It does suggest that a major portion of its shifts over time can be explained by variations in "real" farm prices.

[36]Evaluating elasticities at extreme points on linear relations has disadvantages unless the linearity is real. This is in addition to the lower statistical reliability of the coefficient at the extreme points on the relation.

Supply elasticities. The supply elasticities are summarized in Table 2. The coefficient of adjustment implied by Model I is .32,[37] indicating that 32% of the discrepancy between equilibrium and actual employment is removed in a given time period. Eight years are required to eliminate 95% of a given disequilibrium, assuming other factors remain unchanged.[38] This co-efficient of adjustment implies long run elasticities that are approximately three times as large as the short run elasticities, the short run referring to the response within one year.

The short run supply elasticity with respect to agricultural wage is .25, at the means. The "corrected" non-farm income has an elasticity of -.36, somewhat larger than for agricultural wage. This indicates that suppl-iers of labor have responded somewhat more quickly to non-farm income incen-tives than to farm income incentives.

The elasticity of the civilian labor force variable is 1.21, somewhat greater than one. Taken literally this finding implies that a one percent increase in the civilian labor force leads to a greater than one percent in-crease in the quantity of hired labor offered to agriculture, other things remaining constant. On the surface, this might indicate a strong preference

[37]/The adjustment refers to the year to year changes in average employ-ment over the entire year, and not to seasonal variation within the year. The same applies to the coefficient of adjustment in the supply equation.

[38]/Intuitively, eight years seems to be a long time for a given dis-equilibrium to exist. But it is important to recognize the institutional characteristics of the farm labor market. Alternative employment usually involves moving long distances, with the concommitant separation from family and friends. In addition, the fact that an important part of the hired labor force is composed of younger people from local communities reinforces the lack of immediate alternatives for a large portion of the hired labor force. And finally, when prices and wage rate fluctuate as much as they do in agri-culture, it is reasonable to expect economic decision makers to place less importance on what is currently happening. It is to be expected, then, that the adjustment process would be slow. The inference is tempered by noting that a large proportion of the adjustment is made in two to three years.

Table 2. Selected Supply Elasticities Implied by the Simultaneous Equations Models.

	Agricultural Wage		"Corrected" Nonfarm Income		Civilian Labor Force		Coefficient of Adjustment
	Short'	Long	Short'	Long	Short'	Long	
Model I:							
At means	.25	.78	-.36	-1.11	1.21	3.78	.32
At 1957 levels	.48	1.50	-.68	-2.14	1.90	5.94	
Model III:							
At means	.18	--	-.18[a]	--	1.86	--	1.00[b]
At 1957 levels	.36	--	-.36[a]	--	2.93	--	

Notes: Superscript "a" denotes an elasticity computed from a parameter esti-mate that is not significant at the usually accepted level of 5% or better

' Superscript "b" denotes an assumed coefficient of adjustment. This equation was estimated in the traditional static context.

by members of the labor force for employment in agriculture. Alternatively it could reflect the fact that members of the labor force have at times been forced into agricultural employment. This would be especially true during the declines in nonfarm economic activity, when jobs are at least available in agriculture, though at a lower wage.

A more probable explanation is based on the historically higher birth rate in agriculture than in the nonfarm sector. The first employment for a large proportion of the labor force has therefore been in agriculture, and this is where they first appear as members of the labor force. It reflects the continuing over-supply of labor in the agricultural industry and the continued need to transfer resources to the nonfarm sector as a result of the differential rates of entry into the labor force among industries.

In a final interpretation of this elasticity some elements of the latter two explanations are probably involved. The differential birth rate, which induces a greater number of people to at least begin their employment

activities in agriculture,[39] probably plays a role as does the fact that

at times mobility out of agriculture has been restricted by the lack of non-

farm job opportunities. Less credence is given to the suggestion that it

represents stronger preferences for agricultural employment than for other

forms of employment, though this is a possibility.

Evaluating the elasticities at the more recent 1957 levels results in

almost a doubling of each of the relevant elasticities. This is a reflection

of the secular increase in each of the independent variables concurrent with

a decline in the employment in agriculture. Economic progress has resulted

in a continual upward or leftward shifting of the supply curve of hired labor

offered to agriculture.

The elasticities from Model III reflect the combination of both long

run and short run adjustments. The absolute magnitude of the elasticities

was expected to be between the short run and long run elasticities of Model

I, though this was the case only with the civilian labor force variable. As

indicated this is probably due to the lack of significance for the coeffi-

cient of the non-farm income variable.

Demand elasticities. The demand elasticities are summarized in Table 3.

The coefficient of adjustment implied by Model I is .30, indicating that 30

percent of the discrepancy between equilibrium and actual employment is eli-

minated in a given period of time by the demanders of labor. This is slightly

lower than the coefficient of adjustment on the supply side, and would require

[39]Supporting this hypothesis are data showing that large numbers of
the hired labor force in agriculture are farm children and adolescents, who
receive pay from their parents or from working on neighboring farms. Docu-
mentation is provided in An Analysis of the Experienced Hired Farm Working
Force, 1948-1957, Agricultural Information Bulletin No. 225, Agricultural
Marketing Service, United States Department of Agriculture, April, 1960.
This study showed, among other things, that of the farm wage workers in
1957, 42% were between 14-24 years of age in 1958. The study further indi-
cates that "the great majority of persons who ever do farm wage work do so
only for a relatively short period of their lives" (p. 8).

Table 3. Selected Demand Elasticities Implied by the Models.

	Agricultural Wage		Real Farm Prices		Technology		Coefficient of Adjustment
	Short	Long	Short	Long	Short	Long	
Simultaneous Equations Models:							
Model I							
At means	-.12	-.40	.15	.52	$-.14^a$	$-.45^a$	.30
At 1957 levels	-.23	-.77	.19	.64	$-.22^a$	$-.72^a$	
Model III							
At means	-.31	--	.33	--	-.57	--	1.00^b
At 1957 levels	-.60	--	.41	--	-.90	--	
Single Equation Models:							
Model I							
At means	-.12	-.40	.15	.51	$-.14^a$	$-.46^a$	.30
At 1957 levels	-.22	-.74	.19	.64	$-.22a$	$-.73^a$	

Notes: Superscript "a" denotes an elasticity computed from a parameter
estimate that is not significant at the usually accepted level of
5% or better.

Superscript "b" denotes an assumed coefficient of adjustment.

between eight and nine years to eliminate 95% of a given disequilibrium,
assuming other factors remain unchanged.[40/] This coefficient of adjustment
also implies long run elasticities that are slightly more than three times
as large as the short run elasticities.

Evaluated at the means the short run elasticity of demand for agricul-
tural labor with respect to agricultural wage rates is -.12, considerably
lower than the supply elasticity. Real farm prices have a short run elasti-
city of .15 and technology has a short run elasticity of -.14, though the
latter is computed from a parameter estimate that is not significant at
usually accepted levels. To the extent that technology has been an exogen-
ous force in the labor market it has acted to reduce the quantity of labor

[40/]Comments similar to those suggested when discussing the coefficient
of adjustment for suppliers are also relevant when interpreting this coeffi-
cient.

demanded. Not much reliability can be attached to this inference, however, since the standard error is almost as large as the parameter estimate.

The elasticities of Model III lie between the short and long run elasticities of Model I for both agricultural wage and real farm prices. For technology, however, the elasticity is larger than the long run elasticity of Model I. This is related to technology being significantly different from zero in Model III, but not in Model I.

Similar to the supply relation, the demand elasticities from all models at the 1957 level of their variables result in estimates approximately twice as large as at the means for both agricultural wage and technology. However, since real farm prices in 1957 were only slightly below their mean value, there was very little change in this elasticity when evaluated at the mean. The slight reduction in prices offset the decline in employment when taken as a ratio.

Comparison with other studies. To the author's knowledge no empirical estimates of the labor supply function to the agricultural industry exists. Griliches,[41] however, has made estimates of the demand relation for hired labor, using both distributed lag models and the more conventional static approach. Though he used quite different models and restricted himself to ordinary least squares estimation procedures the results compare well.

When using the distributed lag model he obtained a short run elasticity at the mean for agricultural wage of -.11, which is very close to the estimate above of -.12. His much lower coefficient of adjustment of .18 resulted in a long run elasticity of -.62, which is somewhat larger than the estimate of -.40 obtained in this study. Griliches' coefficient of adjustment was quite low because he used only a very simple model. He omitted technology

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[41]Griliches, Zvi, "The Demand for Inputs in Agriculture and a Derived Supply Elasticity", Journal of Farm Economics, Vol. 41, May, 1959, pp. 316.

and the prices of other factors of production, both of which are included in the models developed above. This led to specification bias for the parameter of lagged employment.

The elasticity Griliches obtained from the static model was somewhat larger than the one obtained above, his result being a -.52 compared to the -.29 and .31 obtained when hired employment was taken as the dependent variable. But given that quite different models and measurement concepts were employed, the results are reconcilable.

Other General Implications

"Corrected" nonfarm income. In order to capture the effects of unemployment in the nonfarm sector as a determinant of the supply of labor offered to agriculture it was necessary to synthesize a new nonfarm income concept. This concept assumes basically that when a laborer compares his farm and nonfarm earnings he forms an expected value of the nonfarm earning possibilties based on the amount of unemployment in the nonfarm sector. It assumes that he discounts the pecuniary earnings he will obtain if employed by the probability of being unemployed if nonfarm employment is taken. This probability is determined by the proportion of the present labor force unemployed on the assumption that if unemployed his income is zero.

Though no direct evidence is available to test or confirm this hypothesis the indirect evidence tends to substantiate its validity. The concept results in much better statistical results than when pecuniary earnings and unemployment were entered as separate variables. It consistently permitted a more adequate identification of the parameter of agricultural wage in the supply relation when used in the various models. And in addition, when its elasticity is evaluated in the reduced form context, [42/] one percent

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[42/]See forthcoming article.

increases in its value tend to be associated with one percent increases in agricultural wages, other things being equal. This provides some evidence that the concept is equivalent to agricultural wages considered with certainty.

These two pieces of indirect evidence indicate that in making the continual adjustment from agricultural employment to nonfarm employment, members of the labor force consider their wages in agriculture with certainty, since unemployment does not develop there, and form an "expected" value of nonfarm earnings based on their pecuniary earnings if employed, and the probability of being unemployed. This in itself would suggest that the equilibrium level of real pecuniary earnings in nonfarm employment could be higher than farm earnings by a sufficient amount to compensate for the possibility of being unemployed. Hence, the hypothesis has substantive implications.

Technology in agriculture. Griliches,[43] has recently argued that the increase in fertilizer use in American agriculture could be explained by the decline in the real price of this input. The implication of this is that technological change has not taken place internal to the agricultural industry, but rather in the supply industries serving agriculture. Observed behavior can be interpreted by assuming an unchanging production function in agriculture, with changing relative price of inputs changing the proportions in which resources are used.

Two pieces of evidence from this study tend to substantiate this hypothesis. In the first place it has been difficult to obtain a significant coefficient for technology in the demand equation. The only models in which it is significant are those in which the distributed lag hypothesis is dropped, and in that case it may be a spurious relationship.

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[43]Griliches, Zvi, "The Demand For Fertilizer: An Economic Interpretation of a Technological Change," Journal of Farm Economics, August, 1958, pp. 591-606.

This by itself is only weak evidence of an unchanging production function, however. Certain combinations of (a) technical change in the farm and non-farm sectors, (b) changes in the real price of labor, and (c) changes in the price of product, could lead to a parameter for technology that would not be significantly different from zero. The failure to find a significant relationship is consistent with the hypothesis of no change in the production function, however.

But the success in estimating the demand relation by ordinary least squares and the comparibility of the parameter estimates with those obtained when simultaneous equations procedures are employed indicate that the demand relation has been relatively stable over time, with variations in real farm prices accounting for most of its shifts. And a stable demand for an input, since it is a derived demand, indicates a stable production function. This is evidence of a much stronger nature than the failure to find a significant coefficient for technology.

This is not to deny that there has been some changes in the production function in agriculture. It does suggest, however, that these changes, in terms of the transformation rate of input services into output services, within agriculture, have been rather small, and that a major portion of the changes in resource use observed in agriculture is a result of changing relative prices of inputs on a stable production function.

Resource misallocations of present farm programs. It has been argued by many that present farm programs have not been a deterrent to the needed movement of labor resources out of agriculture. Mumey,[44] in a recent article cites empirical evidence in support of this thesis.

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[44]/Mumey, Glen A., "The Parity Ratio and Agricultural Out-Migration", The Southern Economic Journal, July, 1959, pp. 63-65. This is a good example of how mistaken inference can be drawn by relying on simple correlations when much more complicated relationships are involved.

The results of the present study do not support this argument. The rather sizeable price elasticity for the labor supply function, both in the short run and in the long run, indicate that increases in demand for labor within agriculture can lead to substantial transfers of resources to the farm sector. In addition, the positive elasticity of real farm prices in the demand function indicates that raising farm prices through support operations does lead to upward shifts in the demand function for hired labor. An ultimate measure of the welfare losses and/or gains to society from the support operations would be dependent on the degree to which prices are set above their equilibrium level, the elasticity of demand for labor with respect to real farm prices, and the relative supply and demand elasticities for labor with respect to agricultural wage. Though no empirical estimate of these magnitudes are presented, the elasticities presented above indicate that the welfare losses can be quite large.