1973

A. Econometric models of the labor market in the farm sector of the north central region of the United States, B. The demand for farm labor in the United States

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A. Econometric models of the labor market in the farm sector of the north central region of the United States

B. The demand for farm labor in the United States

by

Nikolaos Stephanou Martinos

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I. INTRODUCTION

A. Nature of the Problem

The United States agricultural sector has undergone substantial changes since the turn of the century. Since changes in price relationships and technological advances have continually induced greater mechanization of farm operations, the demand for farm labor and, in turn, farm employment opportunities have decreased. The movement of labor out of agriculture began around 1916 with the rate of migration increasing considerably during the past thirty years. During the 1940-1970 period, the farm labor force declined by 41.2 percent (38, p. 30).

In the past two decades, productivity as measured by indexes of output per man-hour has risen much more in the farm sector than in the nonfarm. Starting from an index of 37.7 in 1950, farm output per man-hour went up by 75.4 points to 113.1 in 1970. In comparison, the index of nonfarm output rose from 65.0 in 1950 to 103.8 in 1970, an increase of only 38.8 points. (See Table 1.) On the 1967 base of 100, farm productivity had outpaced nonfarm by 1970 when the farm index of output was 113.1 and nonfarm was 103.8.

Notwithstanding the large increases in agricultural productivity and the drastic decrease in the farm labor force, relative farm wages and relative farm incomes declined. During the 1940-1949 period, the real farm wage

Table 1. Indexes of output per man-hour, 1950-1970 (selected years) (Indexes, 1967=100)[a]

Year	Total Private	Farm	Nonfarm Total	Nonfarm Manu-facturing	Nonfarm Nonmanu-facturing
1950	59.4	37.7	65.0	64.4	65.3
1952	62.7	41.2	66.9	66.2	67.2
1954	66.9	49.1	70.5	69.5	71.0
1956	70.0	51.6	73.2	72.9	73.3
1958	74.3	60.4	76.7	74.4	78.0
1960	78.2	64.9	80.3	79.9	80.6
1962	84.7	71.7	86.4	86.6	86.5
1964	91.1	79.5	92.4	94.5	91.5
1966	98.0	90.5	98.4	99.9	97.6
1968	102.9	101.4	102.9	104.7	101.9
1970[b]	104.6	113.1	103.8	108.1	102.1

[a]Source: (41, p. 317).

[b]Preliminary.

rate[1] was only 40.76 percent of the real wage rate in manufacture,[2] decreasing to 35.65 percent in the 1960-1969 period. Likewise, the ratio of the realized net farm income per

[1]Annual farm wages and salaries per farm worker in U.S. in constant 1957-59 dollars (deflated by prices paid for living expenses).

[2]Annual wages and salaries in manufacture in constant 1957-59 dollars (deflated by C.P. index).

family member[1] to the wage rate in manufacture, dropped from 65.42 percent to 60.52 percent during the same time.

From 1940 to 1970 total farm output increased by 43 percent with total farm inputs increasing by only 12 percent (38, p. 30). The continuous increase of total farm output through relatively small increases in farm inputs and the continuous decline of the farm labor force can be attributed to two major factors: (1) technological developments that changed the aggregate production function in the agricultural sector; and (2) changes in the price of farm labor relative to the price of capital (11, pp. 80-103). Since the price and income demand elasticities for farm products are low, the increased farm output caused by new technological developments in the form of, better agricultural machinery and equipment, biological innovations, fertilizer and chemicals, had as a result depressed farm prices and, in turn, caused low resource returns and farm incomes.

Assuming that the agricultural sector is operating under a free market mechanism, there are at least two ways by which farm incomes can be improved, through output reduction and increasing farm prices, or with unchanged output

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[1]Realized annual net farm income per family member in constant 1957-59 dollars (deflated by prices paid for living expenses).

and a rapidly declining farm labor force, which means that the same aggregate income will be divided among fewer persons. Historical experience shows that it is rather unrealistic to expect a drastic drop in total farm output without strict governmental controls in production.

In order to answer problems concerning overproduction and low factor returns, more must be known about the resource structure. Given the stage of technology, farm output is determined in the short run by the existing resource level. Changes in farm output depend basically upon the flexibility of resources employed in the production process. Since labor is one of the most important inputs, a thorough examination of its structure is needed to facilitate sound economic policy measures.

B. Objectives

In order to be capable of answering questions concerning such basic problems of agriculture as the surplus production and the low farm incomes, it is necessary to have a good knowledge of the structure of the commodity market, and of the structure of the resource market.

This study deals with the structure of the resource market, especially with that of the farm labor force. In particular we shall try to find out which are the structural relationships of the farm labor force market. By structural relationships we mean the demand for and supply of farm labor.

Although it is recognized that there are many non-economic factors that influence the structural relationships of the labor force in the farm sector, this study will focus only on the most important economic factors which can be identified and quantified. It also will attempt to answer questions concerning the demand and supply responses to changing economic conditions. For instance, what will be the effect on the quantity demanded of farm labor if there is a change in the farm wage rate, or in the prices of farm output or in the prices of such related inputs as farm machinery. Is the quantity supplied of farm labor responsive to changes in the farm wage rate, to the nonfarm wage rate? To what extent does the off-farm employment opportunities, as expressed by the U.S. level of unemployment, influence the mobility of the farm labor force?

An econometric model consisting of a set of autonomous (structural) equations will then be constructed for the purpose of explaining the factors that influence the farm labor market. Different hypotheses will be tested, by including in the model the most meaningful explanatory variables, and some predictions concerning future levels of farm employment will be attempted. An effort will also be made to see what the policy implications are, and how the income situation in the farm sector can be improved.

In this study emphasis will be on the farm labor market of the North Central region and especially on the demand side, because the factors that influence the demand can be identified and quantified more accurately than those that influence the supply. However, a number of supply equations for farm labor will be estimated by taking into consideration that noneconomic factors that influence decisions concerning the amount of labor to be supplied, or decisions concerning labor movements into or out of the farm sector are very important, and in some cases overshadow the economic ones. It has also been observed that in cases involving farm operators, the separation of the relevant economic variables in demand and supply variables is not clear cut since it is the same people who demand and supply labor (11, pp. 242-252).

C. Procedure and Organization

This study deals with three categories of farm labor; hired, family, and total (the sum of the previous two categories). The hired and family farm labor are treated separately for the purpose of having a better understanding of the factors that influence the total farm labor market.

In the second chapter the relevant economic literature is reviewed, while in the third the necessary theoretical considerations for this study are discussed.

The fourth chapter deals with the empirical analysis of the farm labor market of the north central region which has been divided into three subregions. All three categories of farm labor are examined; hired, family and total by means of simultaneous and single equation estimation methods. The analysis of each category of farm labor is followed by a summary with economic implications. The analysis of the farm labor market of the north central region ends with a general summary and conclusions.

The fifth chapter deals with the empirical analysis of the U.S. aggregate demand for hired, family and total farm labor. The estimation procedures which are used are those of ordinary and generalized least squares. The analysis of the structure of the aggregate demand for farm labor is ending with summary and conclusions. Finally, in the Appendix, the various problems, concerning the development and transformation of the data which were used in this study, are discussed.

II. REVIEW OF LITERATURE

Due to the fact that in some cases involving farm operators the separation of economic variables in demand and supply variables is not clear cut, since it is the same people who demand or supply farm labor, some earlier studies include in the demand side variables which are more appropriate to be included in the supply function. Bishop (4) for instance, studying the farm labor from the migration point of view, found the most important variables to be non-farm income opportunities and unemployment rates. Jones and Christian (16) examining the situation in the hired farm labor market in three "growth states", Florida, Texas and California, attempted to explain the disparity between the rate of change of man-hour productivity and the rate of change of the farm wage rate. Although no structural demand coefficients have been estimated they conclude that the trends of man-hour productivity diverge because of a growing redundancy in the supply of agricultural labor and they stress the importance of various educational programs for off-farm employment opportunities which are not significant under the existing situation.

Econometric analysis of the demand for farm labor has been made in the last decade by Johnson (14), Heady and Tweeten (11), Tweeten (25), Schuh (22), Schuh and Leeds (23), Tyrchniewicz and Schuh (26, 27), Helmers (12) and

Arcus (1).

Johnson (14) examined both the demand and supply of hired and family farm labor. He analyzed three periods 1910-1957 (1920-1930), 1929-1957, 1940-1947, by using least squares methods and simultaneous equation techniques. He concluded that the quantity demanded for hired farm labor is responsive to the farm wage rate and prices received by farmers especially for the last period (1940-1957). The results concerning the value of farm machinery were inconclusive suggesting that further investigation of the role of this variable is necessary. Johnson studied both the aggregate U.S. labor market and the nine census regions for which the results varied. For the family farm labor demand function, he found again significant coefficients for the farm wage rate and for the prices received especially for the last period 1940-1957; but there was ample evidence of positive serial correlation in the residuals. For the supply of hired farm labor he did not find significant coefficients for the U.S. f. wage rate (although it exhibited the expected sign) and the nonfarm wage rate was significant only at 20 percent probability level. For the supply of family farm labor the coefficients of the farm and nonfarm wage rates were insignificant. Again no definite conclusions were derived for the nine census regions.

Tweeten (25) specified the demand for family farm labor for the U.S. as a function of the ratio of the average wage rate in manufacture to the residual farm income per farm worker, the unemployment rate, the ratio of proprietor's equity to liabilities in agriculture, the percentage of forced sales through bankruptcy, an index of government policies, the stock of productive farm machinery and time. He concluded that for the period of 1926-59, only the income ratio, the unemployment rate, the equity ratio and the time trend had a significant effect on the quantity of family farm labor demanded. In his analysis he used both, least squares methods and simultaneous equations estimation techniques.

The demand for hired farm labor was specified as a function of the ratio of the farm wage rate to prices received by farmers for all commodities, the ratio of farm wage rate to prices paid for operating inputs and machinery, the stock of productive assets, the index of government agricultural policies and a time trend. He concluded that again for the period 1926-59, the farm wage rate, the prices received by farmers, the stock of productive farm assets and time, exhibited significant coefficients with the expected signs.

The supply of hired farm labor was specified as a function of the farm wage rate, the wage rate in manufacture, and a nonfarm wage rate variable adjusted to reflect changes in the unemployment rate. All variables exhibited the expected signs and had significant coefficients.

Heady and Tweeten (11) using similar models of demand of hired and family farm labor extended the analysis on a regional basis. Demand equations for the nine geographical regions were estimated.

Schuh (22) examined both the demand and supply of hired farm labor for the whole U.S. by using simultaneous equation estimation techniques. The demand equation was specified as a function of the farm wage rate, prices received for farm products, price index of other inputs, a measure of technology and a time trend. All variables were significant except for the time trend. The supply equations was specified as a function of the farm wage rate, a measure of nonfarm income, the rate of unemployment and the size of civilian labor force. All parameter estimates of the supply equation were found significant.

Schuh and Leeds (23) made a regional study of the demand for hired farm labor. The demand equation was specified as a function of the farm wage rate, the index of prices received and time. All parameter estimates of the demand equation in all geographical regions except for New England were found significant.

Tyrchniewicz and Schuh (26) studied the regional supply of hired farm labor. In their hypothesis the quantity supplied was assumed to be a function of the farm wage rate, nonfarm income, the size of the civilian labor force and a time trend. Estimates of the parameters were obtained by means of simultaneous equation procedures. The hypothetical variables were found to have significant coefficients in most regions except for New England, the Mountain and Pacific regions.

Tyrchniewicz and Schuh (27) modified their previous hypothesis by assuming that an interrelationship exists among the three components of farm labor (i.e., hired farm labor, operator farm labor, and unpaid family farm labor). For this purpose they used a six-equation distributed lag simultaneous equation model consisting of three demand and three supply equations respectively. However, the coefficient of the lagged endogenous variable in both the demand and supply equations for operator labor was found to be (although not significant) greater than one, which implies a negative coefficient of adjustment. This means that if there is a change in the economic conditions there will be a movement away from equilibrium in the market of operator labor. Time series data (1929-1961) were used.

Helmers (12) studied both, the demand for farm labor for the whole U.S. and for the ten production regions. Seven endogenous variables and a large number of exogenous variables were tested by means of ordinary least squares. Based on the fact that for some kinds of farm labor (i.e., family farm labor) the same person demands and supplies farm labor he specified his model in such a way, so that the demand function contained variables (i.e., total nonfarm income, employees on nonagricultural payrolls, the rate of unemployment) which, according to our opinion, can be considered more of the supply than of the demand type. He used data from 1938 to 1962. He concluded that the demand for farm labor for the U.S. and regional models, is a function of the farm wage rate, farm income, nonfarm income, U.S. unemployment rate, quantity of substitute inputs (other than machinery, land and buildings) in value terms.

Arcus (1) estimated a set of employment equations for farm population, hired, family and total farm labor for the whole U.S. as well as for the ten production regions, and he made projections of the employment level for 1970, 1975, 1980. However, no parameter estimates of the demand or supply equations of farm labor were estimated. The employment equation corresponds to the reduced form equation; however the parameter estimates of this equation were not derived from the parameter estimates of the structural equations but they were obtained directly.

III. THEORETICAL CONSIDERATIONS

A. Economic Framework

1. Methodology

Before we present the empirical model it is considered necessary to summarize in brief this part of the economic theory which contains hypotheses, postulates and assumptions concerning the economic behavior of individuals or groups of individuals related to this study. The following statements will help to clarify the subsequent discussion on this matter.

A model, in a general sense, consists of a set of assumptions from which one or several conclusions can be derived.

The formulation of a model helps us to test the relevance of a certain theory which contains a general hypothesis, by testing a specific part against the real world (i.e., against a specific set of data). The economic model is related to the real world firstly through its assumptions and secondly through its conclusions. The purpose of constructing an economic model is to provide explanations and predictions concerning certain phenomena of the real world. Milton Friedman (9) argues that a certain theory cannot be tested on the basis of the realism of its assumptions. Although the theoretical assumptions need not represent the real world, they must contain its relevant aspects.

Friedman's position may lead to the construction of such a model which may predict accurately but it may not have any explanatory power. Besides explanation and prediction the model must be good enough in directing us, as to how some of its variables must be altered to bring about desired results in the real world.

In our case the econometric model consists of a set of autonomous equations called structural equations. The parameters of these equations which will be estimated, are called structural parameters. We may think of the economy as being the structure whose various sectors correspond to the autonomous equations. More specifically, by structure we mean "a set of autonomous relationships sufficient to determine the numerical values of the endogenous variables, given the values of the exogenous variables" (6, pp. 15-47), and by econometric model we mean "a set of structures if all the structures in the set are alike in those three respects: the number of equations, the list of endogenous and exogenous variables, and the list of variables that appear in each equation" (6, pp. 15-47). At the outset, the basic assumptions of the perfectly competitive model will be made; as we proceed some of the assumptions will be relaxed, while new ones will be introduced.

2. Static theory of resource demand and supply

a. Demand The starting point for the formulation of the empirical model is the marginal theory of the firm operating under perfect competition with an objective of profit maximization. The underlying assumptions for a perfectly competitive factor market are those of homogeneous resource units, a large number of buyers and sellers, perfect knowledge and freedom of entry; then for a given production function the long run demand[1] for an input depends on its price, the prices of other inputs, and the price of the output (13, pp. 107-108).

$$X_{ik} = f(P_i, P_j, P_y) \tag{3.1}$$

where,

X_{ik} = quantity of input i, for k^{th} firm

P_i = price of input i

P_j = price of related input j $(j=1,2,\ldots,n\neq i)$

P_y = price of output.

The aggregate demand function for input X_i is the summation of all individual demand functions.

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[1]In the short run the quantity of fixed inputs enters the demand function for an input as a parameter (11, pp. 42-49).

b. Supply The individual's (13, pp. 23-24) supply of labor is derived, by the use of consumer utility, as a function of the wage rate.

$$X_{Lk} = f(P_k) \tag{3.2}$$

where,

X_{Lk} = quantity of labor for k^{th} individual

P_k = wage rate.

The aggregate supply function of labor is the summation of all individual supply functions. Since the agricultural labor market is not closed, decisions concerning the amount of labor to be supplied in the farm sector is influenced by nonfarm income and off-farm employment opportunities.

Equation 3.2 thus becomes:

$$X_{Lk} = f(P_F, P_{NF}, u) \tag{3.3}$$

where,

P_F = farm wage rate

P_{NF} = nonfarm wage rate

u = unemployment rate.

3. Dynamic theory of resource demand and supply

It has been observed that individuals do not always adjust instantaneously to changes in economic conditions;

this lag in response is explained by dynamic theory which is "...the study of economic phenomena in relation to proceeding and succeeding events" (3, p. 4). In our context, dynamic theory tries to explain the various changes that occur in the value of the endogenous variables as time passes even in cases when the structural parameters and the set of all the exogenous variables in the model, except time, remain unchanged. Time is the most important element in dynamic theory; it may appear either as an exogenous variable itself (time trend) or as a subscript of a certain variable which takes different values at different (time) periods (i.e., dating of the variables).

With the comparative statics we look in general into two equilibrium situations with no concern about the path that the economic system followed through time. The changes that occur in the endogenous variables are explained in terms of changes in the value of one exogenous variable or one parameter. Dynamics enter into the picture as soon as we introduce a time trend or a lag variable or in cases we are concerned about the stability of the attained equilibrium or about what has happened in between two equilibrium positions.

The agricultural sector is often characterized by a lag in response; it takes a period of time to adjust to new price and marginal productivity ratios once some of the resources have been employed in the production process. In many cases the effects of a change in economic conditions are spread over many time periods. In this case we have a distributed lag. The period of adjustment may differ from a few months to several years. This lag in response may be attributed to such factors as (1) the durability of existing resources, (2) capital limitations, (3) uncertainty concerning future returns and market conditions, (4) lack of information concerning the use of new inputs, (5) such institutional conditions as farm size, tenure and contract arrangements etc. (11, pp. 68-79).

Farm workers and farm operators may not adjust completely within a given time period to changes in relative wages or relative incomes for a number of reasons. (1) It may be considered that the changes in economic conditions are only temporary and it may be estimated that the costs of a fast adjustment is much higher than the possible benefits. (2) Lack of information concerning nonfarm employment opportunities and lack of skills for off-farm work. (3) The various contracts and other obligations that oblige especially farm operators to stay in the farms for a given time period. Thus considering the economic reality, it makes more sense to use, in the demand function for farm labor, stock values of such related inputs as farm machinery than using price indexes. Since it is assumed that no changes occur in the structural coefficients a time trend must be included in the demand function as an indicator of technological change. Since the agricultural input market is not isolated from the rest of the economy, and since the labor force can move in and out of the agricultural sector, a proxy of the nonfarm wage rate must be included in the supply function, or the ratio of the farm versus the non-farm wage rate used as a measure of the relative probability of the farm sector and as an incentive for the farm workers to stay in or move out from agriculture. The U.S. unemployment rate must also be included in the supply function as an indicator of off-farm employment opportunities, as well as a time trend.

a. A note on distributed lags The demand for farm labor is expected to behave less sluggishly than the supply of farm labor; that is, decisions concerning the hiring of additional amounts of farm labor or buying new inputs are made relatively faster than decisions concerning movements of farm workers and operators; that is, to stay in or leave the farms. Therefore the adjustment period on the supply side is expected to be larger than on the demand side. For this reason, last year's farm machinery prices or stock values have been included in the demand for farm labor and the assumption of the distributed lag hypothesis as was developed by Koyck (18) and Nerlove (20, pp. 1-20) has been made as far as the supply function is concerned.

Suppose that y is a linear function of X_1 and X_2. A distributed lag with a Kroyck type transformation will be:

$$y_t = a + bx_{1_t} + b\delta x_{1_{t-1}} + b\delta^2 x_{1_{t-2}} + \ldots + dx_{2_t}$$

$$+ d\delta x_{2_{t-1}} + d\delta^2 x_{2_{t-2}} + \ldots \qquad (3.4)$$

where $0 < \delta < 1$

$$y_t = a + b \sum_{i=0}^{\infty} \delta^i x_{1_{t-i}} + d \sum_{i=0}^{\infty} \delta^i x_{2_{t-i}} \qquad (3.5)$$

$$\delta y_{t-1} = a\delta + b \sum_{i=1}^{\infty} \delta^i x_{1_{t-i}} + d \sum_{i=1}^{\infty} \delta^i x_{2_{t-i}} \quad . \qquad (3.6)$$

Subtracting Equation 3.6 from 3.5 we have

$$y_t - \delta y_{t-1} = a(\delta-1) + bx_{1_t} + dx_{2_t} \qquad (3.7)$$

$$y_t = a(\delta-1) + bx_{1_t} + dx_{2_t} + \delta y_{t-1} \quad . \qquad (3.8)$$

The cumulative effect of a maintained change in x_{1_t} and x_{2_t} is:

$$\sum_{i=1}^{\infty} \delta^i = \frac{1}{1-\delta} \qquad (3.9)$$

the short run elasticity with respect to x_1 estimated at the mean level is

$$e_{SR} = b \frac{\bar{x}_1}{\bar{y}} \tag{3.10}$$

the long run elasticity is

$$e_{LR} = \frac{1}{1-\delta} b \frac{\bar{x}_1}{\bar{y}} \quad . \tag{3.11}$$

Nerlove (21) used a different assumption concerning the cause of the lag, but he derived similar conclusions with Koyck(18). He assumed that there exists a long run demand or supply equation of the form,

$$y_t^* = a + bx_t \tag{3.12}$$

and an adjustment equation of the form,

$$y_t - y_{t-1} = \gamma(y_t^* - y_{t-1}) \tag{3.13}$$

where,

y_t^* is the long run equilibrium level of the quantity demanded or supplied and x_t is the price of y at time t.

y_t is the current quantity demanded or supplied.

The adjustment equation (Equation 3.13) says that the use of y_t would change in proportion to the difference between the long run equilibrium quantity and the current quantity.

Substituting Equation 3.12 into 3.13 we have:

$$y_t = \gamma a + \gamma b x_t + (1-\gamma) y_{t-1} \tag{3.14}$$

which is similar to Equation 3.8.

4. The conceptual model

The first part of the study is concerned with the farm labor market in the north central region which has been divided into three subregions. Three different kinds of farm labor are examined; hired, family, and total.

The hypotheses we are going to test are the following:

(1) The quantity demanded of hired farm labor is a function of a) the real farm wage rate, b) the index of the price of farm output, c) the index of the value of the stock of farm machinery, d) a time trend.

(2) The quantity supplied of hired farm labor is a function of a) the real farm wage rate, b) a measure of nonfarm income, c) the U.S. unemployment rate, d) a time trend. It is also assumed that the farm labor market does not adjust instantaneously to changes in economic conditions. For this reason, it has been hypothesized that the supply for hired farm labor reacts with a distributed lag while last year's farm input prices and farm machinery stocks have been included in the demand function. A proxy of nonfarm income was computed based on the annual wages and salaries per

worker in manufacture; the inclusion of the U.S. unemployment rate in the supply function indicates alternative employment opportunities. By including in the model a U.S. average of nonfarm income and the U.S. unemployment rate, it is implicitly assumed that farm laborers tend to move for alternative employment not only into the industrial centers of their region but throughout the country.

The hypothesis concerning the family farm labor is similar with the hired farm labor. However, in addition to the real farm wages a proxy of the residual farm income is included, to test whether or not family workers and operators exhibit a greater response to changes in farm income rather than to changes in farm wages. For the total farm labor the same hypothesis has been made.

The second part of the study is concerned with the demand for the three different kinds of farm labor in the whole United States. The underlying assumptions are similar with those of the regional model.

a. The time trend as an independent variable The time trend has been included in most of the empirical models. In our analysis no specific index of technological change was defined. In the absence of such an index, time is expected to reflect the long run changes in the farm labor market. Since the distributed lag hypothesis has been made, the time variable is expected to pick up some of the trend from the lagged endogenous variables and to reduce the degree of biasness in the estimated coefficients.

B. Statistical Considerations

In this study different statistical procedures have been employed. Demand and supply equations of farm labor were estimated by single and simultaneous equation techniques. Although the purpose of the subsequent deliberation is not to present the statistical and econometric theory which has been used,[1] the basic econometric and statistical techniques which were employed in this study are briefly discussed below. In addition, these parts of econometric theory, which in our opinion have not been fully considered in some of the past research and have caused a lot of misunderstandings, will be presented in some detail.

1. Single equation estimation

a. The least squares method Some of the equations specified in the following model have been solved simply and some simultaneously. For the single equation approach the least squares method is applicable. A demand or a supply equation in a linear single equation form looks as

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[1]For a basic discussion of problems of econometrics see references 6, 7, 15, 17, 24.

follows:

$$Y_i = \beta_1 + \beta_2 x_{2_i} + \dots + \beta_k x_{ki} + u_i \quad , \quad i=1,2,\dots,n \tag{3.15}$$

where Y is the variable to be explained (endogenous), $x_2,\dots,x_k$ are the explanatory (exogenous) variables, β_i are the true parameters and u_i is a random disturbance. In matrix notation the above equation can be written as

$$Y = x\beta + u \quad . \tag{3.16}$$

The basic assumptions in order to obtain the best, linear and unbiased estimates of the β coefficients are the following.

$$E(u) = 0 \tag{3.17}$$

$$E(uu') = \sigma^2 I_n \tag{3.18}$$

$$x \text{ is a set of fixed numbers} \tag{3.19}$$

$$x \text{ has rank } k < n \text{ (15, pp. 106-107)} \quad . \tag{3.20}$$

Equation 3.16 can be written as:

$$Y = x\hat{\beta} + e \quad . \tag{3.21}$$

In the least squares method, the sum of squares of the deviations

$$\sum_{i=1}^{n} e_i^2 = e'e \tag{3.22}$$

is minimized, and the values of the $\hat{\beta}$ coefficients are obtained in the minimization process (15, pp. 108-138).

2. Simultaneous equation estimation

It is recognized that the degree of interdependence of the various economic relationships is very high. The economic variables are usually determined not only by one, but by the simultaneous operation of several autonomous relations. In this case the assumptions of the general linear model are no longer applicable.

The general simultaneous equation linear model consists of G structural relations. The i^{th} relation at time t is the following:

$$\beta_{i1}y_{1t} + \beta_{i2}y_{2t} + \dots + \beta_{iG}y_{Gt} + \gamma_{i1}x_{1t} + \gamma_{i2}x_{2t} + \dots + \gamma_{ik}x_{kt} = u_{it} \quad . \tag{3.23}$$

The model includes G jointly dependent and k predetermined variables. In matrix notation it may be written as

$$By_t + \Gamma x_t = u_t \tag{3.24}$$

where,

B is a (G x G) coefficient matrix of the jointly dependent variables

y_t is a (G x 1) vector of the jointly dependent (endogenous) variables,

Γ is a (G x k) coefficient matrix of the predetermined variables

x_t (k x 1) vector of predetermined variables, and

u_t is a (G x 1) vector of the disturbances.

The predetermined variables consist of exogenous, lagged endogenous variables and instruments. Assuming that B is nonsingular, the reduced form is:

$$y_t = \Pi x_t + V_t \tag{3.25}$$

where

$\Pi = -B^{-1}\Gamma$ and $V_t = B^{-1}u_t$ (15, pp. 231-268).

The basic assumptions concerning the above model are the following:

$$E(u_{ij}) = 0 \tag{3.26}$$

$$\text{Var } (u_{ij}) = \sigma_j^2 \tag{3.27}$$

$$\text{Covar}(u_{ji}, u_{jk}) = 0 \quad \text{for all j and all } i \neq k \tag{3.28}$$

(j refers to the equation and i to the sample).

In the single equation case the random disturbances were assumed to be independent all but one (endogenous) variable. In the simultaneous equation case we can no longer make the same assumption since in each equation there are more than one jointly dependent (endogenous) variables, therefore the least squares estimation method of the structural coefficients is no longer applicable. However, the random disturbances may be assumed to be independent of the predetermined variables.

$$\text{Covar}(X_{mi}, u_{ji}) = 0 \qquad \text{for} \qquad \begin{array}{l} i=1,2,\ldots,n \\ m=1,2,\ldots,n \\ j=1,2,\ldots,G \end{array} \quad . \tag{3.29}$$

a. A note on identification (15, pp. 240-252) The identification problem is related to the property of the structural model; it actually refers to the question whether or not the coefficients of one particular structural equation can be derived from the reduced form coefficients. If this is the case, the structural coefficients are identifiable. Lack of identification not only means that the structural coefficients cannot be derived from the reduced form coefficients, but also that the structural model is incapable of using the existing data for the purpose of obtaining estimates of the structural coefficients. Identification is independent of the numerical values of the nonzero coefficients; it is determined by the specification of the structural model, especially by the zero structural coefficients (i.e., number of variables missing from the equation).

A structural equation is said to be just identified if the number of the predetermined variables which do not appear in the equation is equal to the number of the endogenous variables in the equation minus one; it is overidentified if the number of the predetermined variables not present in the equation is greater than the number of the endogenous variables in the equation minus one, and underidentified if the missing predetermined variables are less than the number of the endogenous variables in the equation minus one. If the structural equation is underidentified there is no way that the structural coefficients can be inferred from the reduced form coefficients, which means that the model under consideration is incapable of using the existing data for the purpose of obtaining parameter estimates of the structural equations.

The order condition for identification is usually stated as (15, p. 250-251):

$$k^{**} \geq G^{\Delta} - 1 \qquad (3.30)$$

where

k^{**} = number of predetermined variables not present in the equation

G^{Δ} = number of jointly dependent variables in the equation.

3. Statistical procedure

Although the focus of this study is on the demand side, both demand and supply equations have been estimated by single and by simultaneous equations techniques. Also, an effort was made so that the exogenous variables in each equation would show the lowest possible degree of correlation. For this purpose the correlation matrix of all exogenous variables was constructed and consulted. The sample size was also increased to some extent in order to avoid high covariances among the estimated parameters in an equation. Evidently, the way the explanatory variables are chosen is subjective rather than objective. The variables must fulfill two requirements; first to be meaningful as far as economic theory is concerned and second to be uncorrelated among themselves. There are trade-offs between the loss of explanatory power of the model, if one or more exogenous variables are excluded and the problem of multilinearity if they are kept in (15, pp. 201-207).

In the simultaneous equation estimation the model consists of two equations (i.e., the demand for and the supply of farm labor). The quantity of farm labor and the farm wage rate or the farm income are assumed to be mutually determined; since the random disturbances are not assumed to be independent of the jointly dependent variables, the least squares estimation is no longer applicable. Estimates of the structural coefficients are therefore obtained by the method of two-stage least squares (15, pp. 258-263). In the first stage estimates of all endogenous variables but one in the equation, are obtained by treating separately each of them as a linear function of all predetermined variables of the model, and then applying the least squares method. In the second stage, the least squares method is applied by treating the remaining jointly dependent variable in the equation as being the only endogenous, and the estimates of all other jointly dependent as well as the predetermined variables in the equation as truly exogenous.

When the distributed lag hypothesis is made, the dependent variable (i.e., the quantity of farm labor) is lagged one year and treated as exogenous. From its parameter estimate the adjustment coefficient is derived. Short and long run elasticities have also been estimated.

For each equation the Durbin-Watson statistic is estimated to test for autocorrelated disturbances; it is recognized, however, that this statistic is not a strong indicator of autocorrelation, where the lagged endogenous variable is treated as an explanatory variable (10).

In the single equation estimation the least squares method is used. In cases where the Durbin-Watson test showed that the errors were autocorrelated, the parameters estimated by ordinary least squares are no longer appropriate for well known reasons (i.e., underestimation of sampling variances, inefficiency in predictions, etc.) (15, pp. 177-197). In this case it was assumed that the residuals are following a first order Markov-Scheme (i.e., $\hat{u}_t = \rho\hat{u}_{t-1} + e_t$) and then the method of generalized least squares was applied (15, pp. 179-194).

It has also been hypothesized throughout this study that all the variables are measured without error.

IV. EMPIRICAL MODELS OF DEMAND FOR AND SUPPLY OF FARM LABOR IN THE NORTH CENTRAL REGION OF THE UNITED STATES

A. Introduction

The north central region is usually divided into two subregions, the east north central and the west north central. In this study the west north central region was further divided into two subregions; the west north central region (I) and the west north central region (II). Criteria for this division were the relative homogeneity of each subregion from production point of view, and the relative managability of the data. Besides the production differences which the three subregions exhibit among themselves, they are also expected to show a degree of heterogeneity as far as the labor market is concerned. This aspect would be important for the purpose of making interregional comparisons.

Table 2. Division of the north central region into three subregions

North central region	
Subregion	States
East north central or ENC	Ohio, Indiana, Illinois, Michigan, Wisconsin
West north central (I) or WNC_I	Minnesota, Iowa, Missouri
West north central (II) or WNC_{II}	No. Dakota, So. Dakota, Nebraska, Kansas

Time series data from 1939 to 1970 have been the main source of information in this study.[1] Since state data concerning stock values of farm machinery has not been reported earlier than 1945, all models which include this variable refer to the period 1945-1970; however, a number of equations where the machinery variable is not present cover the period 1939-1970. The disadvantage due to the use of a smaller sample size should be offset by the more homogeneous sample in which the war years have been excluded.

Demand and supply equations have been estimated by both simultaneous and single equation methods. A comparison of these two approaches will follow after the presentation of the basic models.

Although most of the models which fail to provide satisfactory explanation have been excluded, a small number of them will be presented for the purpose of showing the overall impact of the inclusion or omission of one or more explanatory variables, and the model building process as well.

Each simultaneous equation model consists of two equations, one demand and one supply equation. In this case the variables have been divided into two groups. The first group consists of the jointly dependent variables which

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[1]For a detailed discussion on the data collection and transformation see the Appendix.

include the quantity of farm labor and the various proxies of its price, while the second group consists of the predetermined variables.

1. Jointly dependent variables

In each model there are two jointly dependent variables, the price and the quantity of farm labor.

In the case of hired farm labor, two proxies were tested as indicators of its price. The first proxy is the farm wage rate, and it is viewed as the price of hired labor in an absolute sense; while the second proxy is an index of the ratio of the farm wage rate versus the nonfarm wage rate, and it is viewed in a relative sense. On the supply side, the wage rate ratio variable shows that decisions concerning the supply of hired farm labor are also influenced by nonfarm variables, such as the wage rate in manufacture; while on the demand side, the wage rate ratio could be viewed as the relative expensiveness of the hired farm labor input.

In the case of family farm labor two proxies were tested as indicators of its price. The first was the already mentioned wage rate ratio and the second the gross per capita farm income. Although it is recognized that a more appropriate proxy for the price of family farm labor would be the net farm income per family member, state data concerning this variable is not reported earlier than 1949. For this reason and since gross farm income is highly correlated to net farm income, the gross per capita farm income proxy was used.

The separate analysis of the hired farm labor market from that of the family farm labor market was considered necessary in order to understand the functioning of the total labor market. The results of the analysis indicated that it was more suitable to use the wage rate ratio variable than the gross per capita income as the price of the total farm labor.

When the demand for and supply of hired farm labor were examined independently, the quantity of farm labor was treated as an endogenous variable; while the farm wage rate lagged one year, and the rest of the explanatory variables were treated as exogenous.

2. Predetermined variables

The predetermined variables consist of exogenous and lagged endogenous variables, which are the following.

a. The time trend As stated in the previous chapter the time trend was used basically as an indicator of technological change; it is expected that it will shift both the demand and supply functions to the left. A shift of the supply curve to the left can be interpreted as the change of the farm labor force's preferences over time. Farm workers might be willing to migrate out of rural areas to larger population centers for noneconomic reasons as well, which cannot be quantified within an analytical framework of this sort. Some of these reasons might be the better communication and transportation in the nonfarm sector, better schooling conditions, better health services and entertainment, etc.

b. The value of the stock of farm machinery It has been stated previously that decisions concerning the demand for farm labor are influenced by the existing stock of farm machinery and equipment rather than the current farm machinery prices. Also, stock values for farm machinery could be developed for each particular region, while state data concerning farm machinery prices were not available. Therefore, the peculiarities of each region were better reflected by the stock values.

c. The U.S. rate of unemployment The U.S. rate of unemployment was used as a nonagricultural variable that influences the mobility of farm labor. By using the U.S. rate of unemployment rather than the prevailing unemployment rate in each region, it was implicitly assumed that when farm labor moves out of the agricultural sector, it will not necessarily stay in the same region but it can move to other regions as well. If favorable conditions prevail in the whole economy, a drop in the unemployment rate would have as a result a shift of the supply curve to the left. This suggests that if the demand function remains relatively stable for a period of time, the quantity of farm labor employed in the agricultural sector will be reduced while the farm wage rate will rise. Had the relative farm wage rate been used as the price of farm labor, the income disparity between the two sectors would have been reduced as well.

d. The index of prices received This variable, deflated by the index of prices paid for living or for production expenses, can be used as an indicator of the relative profitability of agriculture. An increase of this variable is expected to shift the demand for farm labor to the right. This would mean a higher equilibrium level for the farm wage rate and employment. The elasticity of the supply for farm labor would be a crucial factor in this case in influencing farm incomes. If the supply function is inelastic in the short run but elastic in the long run, the impact of a rise in the prices received would be more on the farm employment level than on the farm wage rate. The overall effect would be a decelerated exodus of the labor force from the farm sector which would have a negative effect in increasing farm income.

e. The use of different deflators Due to the heterogeneity of the variables used in the empirical analysis, it was considered as more appropriate to use different deflators for each category of variables rather than using a single deflator. Thus, it was expected that the changes in the real values of the variables would be better reflected. However, in the case of farm machinery two different deflators were used with the purpose of testing their impact on the demand for farm labor.

3. List of variables

The following list includes all the variables which were used in the empirical analysis of the demand for and supply of farm labor. The jointly dependent variables refer to all the simultaneous equation models in all the production regions. In the single equation case, only the quantity of farm labor is treated as an endogenous variable while the farm wage rate is lagged one year and treated as an exogenous variable.

Jointly Dependent Variables:

Y_1^k = Quantity of hired farm labor in 1,000 persons, in the k^{th} region,[1] k=1,2,3,4.

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[1] k=1 for the east north central region; k=2 for the west north central region (I); k=3 for the west north central region (II); k=4 for the north central region.

Y_2^k = Quantity of family farm labor in 1,000 persons, in the k^{th} region, k=1,2,3,4.

Y_3^k = Quantity of total farm labor in 1,000 persons, in the k^{th} region, k=1,2,3,4.

Y_4^k = Index of the composite farm wage rate per hour[1] (1957-59 = 100), deflated by the index of prices paid for living expenses, in the k^{th} region, k=1,2,3,4.

Y_5^k = Ratio of the index of the composite farm wage rate per hour (1957-59 = 100), deflated by the index of prices paid for living expenses, to the index of the hourly wage rate in manufacture (1957-59 = 100), deflated by the consumer price index, in the k^{th} region, k=1,2,3,4 multiplied by 100.

Y_6^k = Gross farm income per capita in constant 1957-59 dollars deflated by prices paid for living expenses (1957-59 = 100) in the k^{th} region k=1,2,3,4.

Predetermined Variables:

X_2 = Time trend[2] (i.e. $t_{1939} = 1$, $t_{1940} = 2$, $t_{1941} = 3$, ..., $t_{1970} = 32$).

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[1]For the definition of the composite farm wage rate per hour see ref. 35, Jan. 1958.

[2]Variables with no subscript are the same in all regions.

X_3^k = Quantity of hired farm labor in 1,000 persons in the k^{th} region, lagged one year (i.e., $X_3^k = Y_{1,t-1}^k$), k=1,2,3,4.

X_4^k = Quantity of family farm labor in 1,000 persons in the k^{th} region lagged one year (i.e., $X_4^k = Y_{2,t-1}^k$), k=1,2,3,4.

X_5^k = Quantity of total farm labor in 1,000 persons in the k^{th} region lagged one year (i.e., $X_5^k = Y_{3,t-1}^k$), k=1,2,3,4.

X_6^k = Value of the stock of farm machinery in constant 1957-59 million dollars, in the k^{th} region (deflated by the index of prices paid for farm machinery, 1957-59 = 100), lagged one year, k=1,2,3,4.

X_7^k = Value of the stock of farm machinery in constant 1957-59 million dollars, in the k^{th} region (deflated by the index of prices paid for production expenses, 1957-59 = 100), lagged one year, k=1,2,3,4.

X_8 = The U.S. rate of unemployment.

X_9 = Index of prices received by farmers for farm products, 1957-59 = 100.

X_{10} = Index of prices received by farmers for farm products, 1957-59 = 100, deflated by the index of prices paid for living expenses, 1957-59 = 100.

X_{11}^{k} = Index of the composite farm wage rate per hour (1957-59 = 100), deflated by the index of prices paid for living expenses, in the k^{th} region, lagged one year (i.e., $X_{11}^{k} = Y_{4,t-1}^{k}$), k=1,2,3,4.

X_{12}^{k} = Ratio of the index of the composite farm wage rate per hour (1957-59 = 100), deflated by the index of prices paid for living expenses, to the index of the hourly wage rate in manufacture (1957-59 = 100), deflated by the CPI, in the k^{th} region, lagged one year (i.e., $X_{12}^{k} = Y_{5,t-1}^{k}$), multiplied by 100, k=1,2,3,4.

4. A brief description of the simultaneous and single equations models

All models which served to test the hypothesis concerning the farm labor market are presented in the following tables.

As stated previously, each simultaneous equation model consists of one demand and one supply equation. The values of the estimated coefficients are placed in front of each variable; two stars above each coefficient indicate that the coefficient is significant at a 5 percent probability level or better, one star that it is significant at 10 percent, and no star that it is not significant. The numbers in parentheses under the estimated coefficients show their standard errors. For each equation the coefficient of determination is presented as an indicator of a good fit and the Durbin-Watson statistic as an indicator of serial correlation among the residuals.

The procedure of testing the hypothesis concerning the farm labor market was gradual in order to observe the impact of the inclusion or omission of a certain variable. Models with no good statistical results have also been included in the following tables for the purpose of showing the model building process. When two proxies were used as the price of farm labor, the same model appears in two different forms (i.e., each including one price proxy respectively). By following this procedure it is possible to observe the gradual improvement in the results by a mere comparison of the respective models. The same holds true for the farm machinery variable which has been deflated by two different deflators. The distributed lag hypothesis is tested by lagging the endogenous variable[1] one year and treating it as exogenous. From its estimated coefficient δ, the coefficient of adjustment γ is derived (i.e., $\delta = 1-\gamma$) showing the speed toward a new equilibrium position. If $\delta=0$, it follows that $\gamma=1$, which implies that there is no lag in response. If $\delta=1$, then $\gamma=0$, which implies that there is no adjustment at all. The smaller the coefficient of

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[1]In this case it is the quantity of farm labor.

adjustment, the longer it takes for the supply to adjust to the new conditions. As the farmers' information increases concerning the functioning of the factor and product markets the lag in response is expected to shorten.

A coefficient of the lagged endogenous variable larger than one implies a negative coefficient of adjustment which shows that there will be a movement away from equilibrium. One possible explanation for such an inconsistent result with the initial hypothesis would be the incorrect specification of the distributed lag model.

The single equation demand and supply models test the same hypothesis as the simultaneous equation models. The parameter estimates of each equation are obtained independently by means of the least square's method.

In each production region the simultaneous equation models which are presented first are followed by the single equation models. The focus of the analysis will be on the models which give the most satisfactory explanation of the farm labor market. For each category of farm labor and for every region the results will be summarized. A general summary with conclusions will follow at the end.

B. Hired Farm Labor

1. Hired farm labor for the east north central region[1]

a. Simultaneous equation models of hired farm labor

(1) Model 1 The demand for hired farm labor is specified as a function of the farm wage rate, the stock value of farm machinery deflated by prices paid for production expenses, a time trend as a technology variable, and the quantity of hired farm labor lagged one year showing that the demand responds with a distributed lag to changes in economic conditions.[2] All variables exhibit the expected signs, except for the farm machinery variable; however, none of the parameter estimates is significant, even at a 10 percent probability level.

The supply of hired farm labor is specified as a function of the farm wage rate, the U.S. unemployment rate, a time trend, and the quantity of hired farm labor lagged one year for the distributed lag hypothesis. All estimated coefficients, except the time trend, exhibit signs that are opposite than those that would be expected and are not statistically significant.

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[1]All variables have the definition given before.

[2]This is a departure from the initial assumption (i.e., in the case of simultaneous equation estimation it is assumed that only the supply behaves in a distributed lag fashion).

As a concluding remark, model 1 does not give any explanation concerning the hired farm labor market whatsoever. All the parameter estimates of each equation of model 1 are presented in Table 3.

(2) Model 2 Model 2 differs from model 1 in the sense that no distributed lag hypothesis has been made concerning the demand and supply functions. Instead, the index of prices received by farmers for farm products, X_{10}, deflated by the index of prices paid for living expenses has been added to the demand function. The only improvement in relation to model 1 is the significant coefficient of the farm wage rate, Y_4^1, in the demand function and the positive but insignificant coefficient of the U.S. unemployment rate, X_8, in the supply function. The estimated parameters of model 2 appear in Table 3.

(3) Model 3 The demand is specified as a function of the farm wage rate, the stock value of farm machinery deflated by the price index of farm machinery, X_6^1, and a time trend. All estimated coefficients, except for the time trend, exhibit the expected sign; but only the farm wage rate, Y_4^1, is significant. The farm machinery coefficient appears insignificant, though with the expected negative sign showing the substitutability of capital for labor. In this model the distributed lag assumption has been hypothesized only for the supply of farm labor, due

Table 3. Simultaneous equations models of hired farm labor for the east north central region

	Constant term		d[a]	R^2[b]
		Model 1		
Demand	$Y_1^1 = \underset{(340.33)}{416.37}$	$- \underset{(2.732)}{2.836} Y_4^1 - \underset{(1.568)}{.602} X_2 + \underset{(.627)}{.151} X_3^1 + \underset{(.038)}{.006} X_7^1$	1.74	.991
Supply	$Y_1^1 =$	$- \underset{(5.253)}{3.644} Y_4^1 - \underset{(2.860)}{.015} X_2 - \underset{(1.100)}{.007} X_3^1 \quad - \underset{(3.111)}{.493} X_8$	1.74	.991
		Model 2		
Demand	$Y_1^1 = \underset{(85.24)}{394.0^{**}}$	$- \underset{(1.257)}{4.452^{**}} Y_4^1 + \underset{(3.095)}{1.864} X_2 + \underset{(.829)}{1.038} X_{10} + \underset{(.009)}{.009} X_7^1$	1.43	.976
Supply	$Y_1^1 = \underset{(90.9)}{468.0}$	$- \underset{(1.333)}{3.024^{**}} Y_4^1 - \underset{(2.357)}{1.056} X_2 \quad + \underset{(3.892)}{.997} X_8$	1.09^{I}	.973

[a]The following notations are true for the tables to follow: d = Durbin-Watson statistic; C = the supperscript C on the Durbin-Watson statistic shows that the disturbances are autocorrelated at 1% prob. level; I = the superscript I on the Durbin-Watson statistic shows that the test is inconclusive at 1% prob. level; absence of a superscript means that we have accepted the hypothesis of random disturbances.

[b]R^2 = coefficient of determination (this applies to following tables).

**The parameter estimate is significant at 5% probability level or better (this applies to following tables).

*The parameter estimate is significant at 10% probability level (this applies to following tables).

to the fact that decisions concerning the movement of labor in and out of agriculture exhibit a longer lag in response in relation to decisions concerning other agricultural inputs. However, model 3, as it is, does not support the above hypothesis because in the supply equation, both the wage rate and the lagged endogenous variable coefficients appear with a negative sign. The estimated parameters of model 2 appear in Table 4.

(4) Model 4 The demand function is the same as in model 3. The only difference is that the time trend has been added to the supply function. The inclusion of the time trend has improved the results on the supply side. Now all the supply coefficients, although not significant, exhibit the expected sign. The parameter estimates of model 4 appear in Table 4.

(5) Model 5 The demand function is that of model 4, plus the prices received for farm products variable, X_{10}. In the supply no distributed lag response has been hypothesized; the U.S. unemployment rate is included instead of the lagged endogenous $Y_{1_{t-1}}$. The prices received variable appears with the expected sign, but it is not significant; while both the time trend, X_2, and the machinery variable, X_6, appear with signs opposite than those expected. On the supply side there was no significant improvement. The unemployment variable, X_8, although

Table 4. Simultaneous equations models of hired farm labor for the east north central region

		Constant term					d[a]	R^2[b]
				Model 3				
Demand	$Y_1^1 =$	508.46** (29.84)	$- 3.602^{**}Y_4^1$ (.419)	$+ .050\ X_2$ (.912)	$- .0013\ X_6^1$ (.0034)			.980
Supply	$Y_1^1 =$	558.64** (176.34)	$- 3.990^{**}Y_4^1$ (1.227)			$- .1059\ X_3^1$ (.3576)		.978
				Model 4				
Demand	$Y_1^1 =$	508.46** (29.84)	$- 3.602^{**}Y_4^1$ (.419)	$+ .050\ X_2$ (.912)	$- .0013\ X_6^1$ (.0034)			.980
Supply	$Y_1^1 =$		$1.587\ Y_4^1$ (13.347)	$- 2.178\ X_2$ (5.189)		$+ 1.179\ X_3^1$ (3.084)		.974

exhibiting the expected positive sign, is insignificant. The farm wage rate shows a negative coefficient. All parameter estimates of model 5 are presented in Table 5.

(6) Model 6 This model is basically the same as the previous one; the only difference is that the prices received for farm products variable has been omitted. There is a slight improvement in the results, especially in the signs of the time trend, X_2, and in the machinery variable, X_6^1. All estimated parameters of model 6 are presented in Table 5.

(7) Model 7 The demand for hired farm labor is specified as a function of the ratio of the farm wage rate to the wage rate in manufacture (i.e., Y_5^1), the stock value of farm machinery, X_6, and a time trend, X_2. A distributed lag adjustment has been hypothesized for the supply which is also considered to be a function of the farm wage rate ratio.

Note that with a specification such as this there was a considerable improvement in the results. Now all parameter estimates appear significant at 5 percent probability level or better and they exhibit the expected sign. However, the coefficient of the lagged endogenous variable ($X_3^1 = Y_{1_{t-1}}^1$), must be viewed with caution because it is greater than one implying that there will be a movement away from equilibrium. All parameter estimates of model 7

Table 5. Simultaneous equations models of hired farm labor for the east north central region

	Constant term	d[a]	R^2[b]
	Model 5		
Demand	$Y_1^1 = \underset{(75.85)}{447.92^{**}} - \underset{(.986)}{3.919^{**}} Y_4^1 + \underset{(2.554)}{1.270} X_2 + \underset{(.0061)}{.0020} X_6^1 + \underset{(.576)}{.483} X_{10}$		.957
Supply	$Y_1^1 = \underset{(71.16)}{481.11^{**}} - \underset{(1.041)}{3.219^{**}} Y_4^1 - \underset{(1.848)}{.717} X_2 + \underset{(3.191)}{.511} X_8$		.955
	Model 6		
Demand	$Y_1^1 = \underset{(52.18)}{496.32^{**}} - \underset{(.741)}{3.426^{**}} Y_4^1 - \underset{(1.582)}{.310} X_2 - \underset{(.0053)}{.00052} X_6^1$		.956
Supply	$Y_1^1 = \underset{(70.78)}{486.6^{**}} - \underset{(1.036)}{32.99^{**}} Y_4^1 - \underset{(1.838)}{.576} X_2 + \underset{(3.170)}{.307} X_8$		.956

Table 6. Simultaneous equations models of hired farm labor for the east north central region

	Constant term	d^{a}	R^{2b}
	Model 7		
Demand	$Y_1^1 = \underset{(41.10)}{607.56^{**}} - \underset{(.335)}{2.877^{**}}Y_5^1 - \underset{(.327)}{6.575^{**}}X_2 - \underset{(.004)}{.009^{**}}X_6^1$	1.55	.980
Supply	$Y_1^1 = \underset{(19.32)}{-73.71^{**}} + \underset{(.207)}{.669^{**}}Y_5^1 + \underset{(.032)}{1.040^{**}}X_3^1$	1.54	.979
	Model 8		
Demand	$Y_1^1 = \underset{(41.10)}{607.56^{**}} - \underset{(.355)}{2.877^{**}}Y_5^1 - \underset{(.327)}{6.575^{**}}X_2 - \underset{(.004)}{.009^{**}}X_6^1$	1.55	.980
Supply	$Y_1^1 = \underset{(1.116)}{.133}\ Y_5^1 - \underset{(2.582)}{1.262^{**}}X_2 + \underset{(.376)}{.856^{**}}X_3^1$	1.50	.978

are presented in Table 6.

(8) Model 8 Model 8 is essentially the same as model 7. The only difference is that a time trend has been added to the supply function, slightly altering the results. The lagged endogenous variable no longer appears with a coefficient greater than one. In addition, the wage rate ratio coefficient, although positive, appears as insignificant.

(9) Model 9 To the demand function of the previous model the prices received for farm products variable, X_{10}, has been added. The effects of the inclusion of X_{10} in the model were similar as in model 5. The machinery variable coefficient, although it exhibits the expected negative sign, is no longer significant; and X_{10} appears with the expected positive sign, but is not significant. On the supply side, the distributed lag assumption has been dropped. The U.S. unemployment rate variable has replaced the lagged endogenous variable with no significant improvement in the results. Note that the sign of the wage rate ratio coefficient is now negative.

(10) Model 10 It is essentially the same with model 9, though the prices received variable has been dropped. The results, however, show no significant change. All parameter estimates of model 10 are found in Table 7.

Table 7. Simultaneous equations models of hired farm labor for the east north central region

		Constant term					d[a]	R^2[b]
Model 9								
Demand	$Y_1^1 =$	510.81**	$- 2.997^{**}Y_5^1$	$- 5.768^{**}X_2$	$- .0037\ X_6^1$	$+ .652\ X_{10}$	1.57	.958
		(78.34)	(.754)	(.984)	(.0064)	(.604)		
Supply	$Y_1^1 =$	454.88**	$- 1.680^{**}Y_5^1$	$- 6.909^{**}X_2$		$+ 2.763\ X_8$	1.32	.955
		(63.48)	(.550)	(.354)		(2.646)		
Model 10								
Demand	$Y_1^1 =$	563.22	$- 2.509^{**}Y_5^1$	$- 6.667^{**}X_2$	$- .0060\ X_6^1$		1.42	.956
		(66.36)	(.542)	(.491)	(.0062)			
Supply	$Y_1^1 =$	462.9	$- 1.741^{**}Y_5^1$	$- 6.930^{**}X_2$		$+ 2.549\ X_8$	1.40	.956
		(63.10)	(.546)	(.350)		(2.621)		

b. Single equation models of the demand for hired farm labor   In the single equation approach the farm wage rate is treated as an exogenous variable; therefore, it is lagged one year. If our analysis explains a substantial part of the variation in the dependent variable (i.e., the quantity of farm labor), the degree of specification error must be small. This is confirmed by the equations estimated using both simultaneous and least squares methods.

(1) Equation 1   The demand for hired farm labor is specified as a function of the farm wage rate lagged one year, and of the time trend. The low value of the Durbin-Watson statistic is an indication of serial correlation in the composite disturbance term; but since the specification is not complete, due to the omission of some possible explanatory variables, the actual error term need not necessarily be serially correlated. Both explanatory variables appear significant with the expected sign. All parameter estimates of equation 1 are found in Table 8.

(2) Equation 2   This equation is obtained from equation 1 by adding the stock value of the farm machinery variable which appears as insignificant and with a positive coefficient. All parameter estimates are presented in Table 8.

Table 8. Demand equations for hired farm labor for the east north central region

Equation no.	Time period	Constant term		d^a	$R^{2\,b}$
1	1939–70	$Y_1^1 = \underset{(22.96)}{435.53^{**}}$	$- \underset{(.394)}{2.514^{**}}X_{11}^1 - \underset{(.684)}{1.835^{**}}X_2$	.633[c]	.978
2	1945–70	$Y_1^1 = \underset{(36.76)}{414.69^{**}}$	$- \underset{(.455)}{2.361^{**}}X_{11}^1 + \underset{(.0054)}{.0053}\ X_7^1 - \underset{(1.319)}{3.558^{**}}X_2$	.693[c]	.979
3	1945–70	$Y_1^1 =$	$\underset{(.673)}{.173}\ X_{11}^1 - \underset{(.002)}{.0074^{**}}X_7^1 + \underset{(.180)}{.977^{**}}X_3^1$	1.621	.974
4	1945–70	$Y_1^1 = \underset{(43.22)}{416.16}$	$- \underset{(.493)}{2.372^{**}}X_{11}^1 + \underset{(.0048)}{.0031}\ X_6^1 - \underset{(1.018)}{2.923^{**}}X_2$	.701[c]	.979

(3) Equation 3   In this equation the distributed lag hypothesis has been made. The farm machinery variable and the lag endogenous variable appear with significant coefficients and with the expected signs, while the farm wage rate has a positive but insignificant coefficient. All parameter estimates are presented in Table 8.

(4) Equation 4   The only difference between this equation and equation 2 lies in the fact that different deflators have been used for the farm machinery variable. Signs and significant coefficient levels are similar.

The single equation method, with respect to the farm wage rate and the time trend, gives similar results with the simultaneous equation approach. The results concerning the farm machinery variable and the distributed lag hypothesis are inconclusive since both positive and negative signs for the same variable have been obtained. All parameter estimates are presented in Table 8.

c. Single equation models of the supply of hired farm labor   In equation 1 the wage rate ratio variable (i.e., farm/nonfarm) lagged one year appears with negative sign. In equation 2, where the distributed lag adjustment has been hypothesized, all variables exhibit significant coefficients at a 5 percent probability level or better and show the expected signs as well. In equation 3 the wage rate ratio appears again with a negative sign. Equation 4 is a combination of the previous two equations, 2 and 3. Although the wage rate ratio and the lagged endogenous variables appear significant with the expected signs, the U.S. unemployment rate appears insignificant but with the expected sign. All parameter estimates of equations 1, 2, 3, and 4 are presented in Table 9.

d. Summary In the simultaneous equation case the models from 1 through 6, though providing little explanation about the hired farm labor market, show gradual improvement in the results when a more appropriate variable is included. The more complete models 7, 8, 9, and 10 support the hypothesis that the demand for hired farm labor is a function of its relative price, the stock value of farm machinery, and of the time trend used as a technology variable. The "index of prices received variable", although exhibiting the expected sign, appears as insignificant (model 9).

The same models, and the single supply equations 2 and 4 of Table 9, support the hypothesis that the supply of hired farm labor is a function of the farm wage rate, the nonfarm wage rate, the time trend; and that it reacts with a lag in adjustment. This specification, however, is not viewed as being completely satisfactory because when the rate of unemployment is introduced the wage rate ratio variable appears with a negative sign. One or more explanatory variables, together with the wage rate in

Table 9. Supply equations of hired farm labor for the east north central region

Eq. no.	Time period	Constant term		d[a]	R^2[b]
1	1939-70	$Y_1^1 = \underset{(36.54)}{440.47}^{**}$	$- \underset{(.373)}{1.535^{**}}X_{12}^1 - \underset{(.325)}{6.331^{**}}X_2$	.454[c]	.965
2	1939-70	$Y_1^1 = \underset{(81.45)}{-163.23}^{**}$	$+ \underset{(.340)}{1.058^{**}}X_{12}^1 - \underset{(1.033)}{1.464^{**}}X_2 + \underset{(.152)}{1.170^{**}}X_3^1$	1.64	.989
3	1939-70	$Y_1^1 = \underset{(47.73)}{354.40}^{**}$	$- \underset{(.439)}{.840^{**}}X_{12}^1 - \underset{(.360)}{5.821^{**}}X_2 + \underset{(1.047)}{2.649^{**}}X_8$	.40[c]	.939
4	1939-70	$Y_1^1 = \underset{(82.78)}{-151.30}^{**}$	$+ \underset{(.402)}{1.087^{**}}X_{12}^1 + \underset{(1.089)}{1.161}\ X_2 + \underset{(.169)}{1.105^{**}}X_3^1 + \underset{(.723)}{.654}\ X_8$	1.63	.990

manufacture and the U.S. unemployment rate, should be included in the supply function to show the interdependence of the agricultural and nonagricultural labor market.

The best results concerning the initial hypothesis are given by model 8 of Table 6. The Durbin-Watson statistic indicates that there is no autocorrelation among the residuals at a 1 percent probability level while the coefficients of determination of the demand and supply functions are .980 and .978 respectively.

A more detailed discussion on the economic implications of the results will follow the presentation of all models concerning the hired farm labor market in the four production regions. The demand and supply elasticities that will be estimated will further clarify the analysis. Then it will also be possible to make interregional comparisons.

2. Hired farm labor for the west north central region I

a. Simultaneous equation models of hired farm labor

Models 1 through 4 are essentially the same as models 5 through 8. The only difference lies in the price of labor variable. In the first four models the farm wage rate Y_4^2 has been used, while in the second four the wage rate ratio variable Y_5^2 has been used. The results in the second group (i.e., models 5 through 8) are significantly better than those of the first group. For these reasons only the second group will be discussed in some detail.

(1) Models 5 and 6 Of the two, model 6 is more complete. It is derived from 5 by adding the time trend to the supply function. The demand is specified as a function of the wage rate ratio, the stock value of farm machinery, and the time trend. All coefficients are significant and exhibit the expected signs. It is hypothesized that the supply reacts in a distributed lag fashion. All the supply coefficients are significant exhibiting the expected signs. All parameter estimates of models 5 and 6 are presented in Table 12.

(2) Models 7 and 8 Model 7 is derived from model 8 by including in the demand function variable X_{10}, which is an index of prices received for farm products. The inclusion of X_{10}, which appears with the expected positive but insignificant coefficient, does not change the results. All other variables appear with significant coefficients and show the expected signs. All parameter estimates of models 7 and 8 are presented in Table 13.

b. Single equation models of the demand for hired farm labor Equations 2 and 3 include the farm machinery variable though with different deflators. The use as a deflator of the price index of farm machinery slightly reduced the standard error of its coefficient, (i.e., from .004 to .003). In equations 4 and 5 the distributed lag

Table 10. Simultaneous equations models of hired farm labor for the west north central region (I)

		Constant term					d[a]	R^{2}[b]
				Model 1				
Demand	$Y_1^2 =$	361.77** (45.28)	$- 1.527^{**}Y_4^2$ (.499)	$- 1.318^{**}X_2$ (.751)	$- .0018^{**}X_6^2$ (.00035)			.978
Supply	$Y_1^2 =$		$.00018\ Y_4^2$ (.757)			$+ 1.015^{**}X_3^2$ (.205)		.974
				Model 2				
Demand	$Y_1^2 =$	361.77** (45.28)	$- 1.527^{**}Y_4^2$ (.499)	$- 1.318^{**}X_2$ (.751)	$- .0018^{**}X_6^2$ (.00035)			.978
Supply	$Y_1^2 =$		$1.467^{**}Y_4^1$ (.501)	$- 3.261^{**}X_2$ (.503)		$+ .663^{**}X_3^2$ (.132)		.976

Table 11. Simultaneous equations models of hired farm labor for the west north central region (I)

		Constant term		d[a]	R^2[b]
Model 3					
Demand	$Y_1^2 =$	$\underset{(42.73)}{396.05^{**}}$	$-\underset{(.612)}{2.016^{**}}Y_4^2 - \underset{(1.058)}{.568}\,X_2 - \underset{(.00037)}{.00189^{**}}X_6^2 + \underset{(.0238)}{.00582}\,X_{10}$		.981
Supply	$Y_1^2 =$		$\underset{(.640)}{2.965^{**}}Y_4^2 - \underset{(.753)}{7.885^{**}}X_2 + \underset{(1.301)}{7.872^{**}}X_8$		.976
Model 4					
Demand	$Y_1^2 =$	$\underset{(41.55)}{397.81^{**}}$	$-\underset{(.457)}{1.927^{**}}Y_4^2 - \underset{(.687)}{.752}\,X_2 - \underset{(.00032)}{.0019^{**}}X_{10}$		.978
Supply	$Y_1^2 =$		$\underset{(.639)}{2.990^{**}}Y_4^2 - \underset{(.753)}{7.914^{**}}X_2 + \underset{(1.298)}{7.913^{**}}X_8$		.974

Table 12. Simultaneous equations models of hired farm labor for the west north central region (I)

		Constant term					d[a]	R^2[b]
				Model 5				
Demand	$Y_1^2 =$	377.18** (50.29)	$- .933^{**}Y_5^2$ (.305)	$- 4.114^{**}X_2$ (.326)	$- .0246^{**}X_6^2$ (.0052)		1.83	.980
Supply	$Y_1^2 =$	−51.19** (9.33)	$+ .764^{**}Y_5^2$ (.134)			$+ .724^{**}X_3^2$ (.061)	1.50	.976
				Model 6				
Demand	$Y_1^2 =$	377.18** (50.29)	$- .933^{**}Y_5^2$ (.305)	$- 4.114^{**}X_2$ (.326)	$- .0246^{**}X_6^2$ (.0052)		1.83	.980
Supply	$Y_1^2 =$		$.508^{**}Y_5^2$ (.173)	$- 1.327^{**}X_2$ (.624)		$+ .522^{**}X_3^2$ (.111)	1.62	.978

Table 13. Simultaneous equations models of hired farm labor for the west north central region (I)

	Constant term	d[a]	R^2[b]
	Model 7		
Demand	$Y_1^2 = \underset{(41.29)}{389.02^{**}} - \underset{(.349)}{1.147^{**}}Y_5^2 - \underset{(.297)}{4.124^{**}}X_2 - \underset{(.0044)}{.0257^{**}}X_6^2 + \underset{(.254)}{.138}\,X_{10}$	1.64	.985
Supply	$Y_1^2 = \underset{(28.61)}{65.37^{**}} + \underset{(.183)}{.846^{**}}Y_5^2 - \underset{(.323)}{3.058^{**}}X_2 + \underset{(.946)}{5.636^{**}}X_8$	1.74	.980
	Model 8		
Demand	$Y_1^2 \quad \underset{(40.57)}{393.64^{**}} - \underset{(.246)}{1.034^{**}}Y_5^2 - \underset{(.279)}{4.182^{**}}X_2 - \underset{(.0043)}{.0260^{**}}X_6^2$	1.62	.982
Supply	$Y_1^2 = \underset{(28.60)}{63.95^{**}} + \underset{(.183)}{.855^{**}}Y_5^2 - \underset{(.323)}{3.042^{**}}X_2 + \underset{(.943)}{5.666^{**}}X_8$	1.59	.979

Table 14. Demand equations of hired farm labor for the west north central region (I)

Eq. no.	Time period	Constant term	d[a]	R^2[b]
1	1939-70	$Y_1^2 = \underset{(36.53)}{246.53^{**}} - \underset{(.437)}{.584^{*}} X_{11}^2 - \underset{(.504)}{3.288^{**}} X_2$	.757[c]	.971
2	1945-70	$Y_1^2 = \underset{(34.72)}{264.34^{**}} - \underset{(.357)}{.690^{**}} X_{11}^2 - \underset{(.754)}{1.440^{**}} X_2 - \underset{(.004)}{.0168^{**}} X_7^2$	1.54	.973
3	1945-70	$Y_1^2 = \underset{(35.96)}{309.18^{**}} - \underset{(.353)}{1.054} X_{11}^2 - \underset{(.522)}{2.120^{**}} X_2 - \underset{(.003)}{.0161^{**}} X_6^2$	1.53	.978
4	1945-70	$Y_1^2 = \underset{(94.27)}{140.85^{*}} - \underset{(.591)}{.021} X_{11}^2 - \underset{(.775)}{1.774^{**}} X_2 - \underset{(.006)}{.010^{*}} X_7^2 + \underset{(.214)}{.300} X_3^2$	1.79	.944
5	1945-70	$Y_1^2 = \underset{(86.35)}{259.55^{**}} - \underset{(.498)}{.885^{**}} X_{11}^2 - \underset{(.004)}{.021^{**}} X_7^2 + \underset{(.223)}{(.150)} X_3^2$	1.55	.986

adjustment was hypothesized. The results did not support the hypothesis. Equations 1 through 5 show that the low value of the Durbin-Watson statistic in the first equation is not due to serial correlation between the actual error terms. The farm wage rate variable lagged one year is treated as an exogenous variable. All estimated parameters of equations 1, 2, 3, 4, and 5 are presented in Table 14.

c. Single equation models of the supply of hired farm labor Equation 4 is the result of the combination of equations 2 and 3. All variables appear with significant coefficients and with the expected signs except for the time trend which has a negative but insignificant coefficient. Equation 4 supports the hypothesis that the supply of hired farm labor is a function of the farm wage rate, the nonfarm wage rate, the U.S. rate of unemployment; and it reacts in a distributed lag type of fashion. All estimated parameters of equations 1, 2, 3, and 4 are presented in Table 15.

d. Summary Models 5 and 6 of Table 12, 7 and 8 of Table 13, and equations 2 through 5 of Table 14, support the hypothesis that the demand for hired farm labor is a function of the wage rate ratio, of the value of the stock of farm machinery, and of the time trend. The "prices received variable", X_{10}, exhibits the expected positive sign (Table 13, model 7), but it is not significant. The

Table 15. Supply equations of hired farm labor for the west north region (I)

Eq. no.	Time period		Constant term		d[a]	R^2[b]
1	1939-70	$Y_1^2 =$	$\underset{(39.19)}{141.47^{**}}$	$+ \underset{(.269)}{.390^{*}} X_{12}^2 - \underset{(.521)}{3.208^{**}} X_2$	$.79^c$	.972
2	1939-70	$Y_1^2 =$		$\underset{(.207)}{.475^{**}} X_{12}^2 - \underset{(.688)}{.632^{**}} X_2 + \underset{(.137)}{.629^{**}} X_3^2$	1.43	.984
3	1939-70	$Y_1^2 =$	$\underset{(37.9)}{128.47^{**}}$	$+ \underset{(.258)}{.431^{*}} X_{12}^2 - \underset{(.506)}{3.016^{**}} X_2 + \underset{(.505)}{.993^{*}} X_8$	$.77^c$	.974
4	1939-70	$Y_1^2 =$		$\underset{(.196)}{.503^{**}} X_{12}^2 - \underset{(.651)}{.606}\ X_2 + \underset{(.131)}{.599^{**}} X_3^2 + \underset{(.385)}{.790^{**}} X_8$	1.46	.986

same models as well as equation 4 of Table 15, support the hypothesis that the supply of hired farm labor is a function of the relative wage rate, of the U.S. rate of unemployment, of the time trend; and it reacts with a distributed lag.

3. Hired farm labor for the west north central region II

a. Simultaneous equation models of hired farm labor
As in the west north central region I, models 1 through 4 of Tables 16 and 17 are similar with models 5 through 8 of Tables 18 and 19. They differ only on the price of labor variable. Models 5 through 8 are more complete and have a better explanatory power; however, Tables 16 and 17 have been included for the purpose of showing the model building process and the impact of omitting or including one or more explanatory variables.

(1) Models 5 and 6 Model 6 is derived from model 5 by adding to the supply function the time trend variable, X_2. The demand is specified as a function of the wage rate, the stock value of farm machinery, and the time trend. All coefficients are significant and exhibit the expected signs. It has been assumed that the supply reacts with a distributed lag type of adjustment. All supply coefficients are significant and exhibit the expected signs. All parameter estimates of models 5 and 6 are

presented in Table 18.

(2) Models 7 and 8 These models are the same with those of Table 13. Model 7 is derived from model 8 by adding to the demand function the "prices received" variable, X_{10}, which appears with the expected positive though insignificant coefficient. All other variables appear with significant coefficients exhibiting the expected signs. The results are presented in Table 19.

b. Single equation models of the demand for hired farm labor The farm wage rate variable in the single equation approach is treated as exogenous. Therefore, it is lagged one year.

Equations 2 and 4 include the farm machinery variable with different deflators. The coefficient of the stock value of farm machinery variable, deflated by the price index of farm machinery, exhibits a smaller variance. In equations 3, 5, and 6 it has been hypothesized that the demand for hired farm labor behaves with a distributed lag type of adjustment. This assumption has been made because the demand for hired farm labor is examined independently from the supply. The results support the hypothesis. The farm machinery variable also appears significant and with the expected negative sign in all equations. All estimated parameters of equations 1 through 6 are presented in Table 20.

Table 16. Simultaneous equations models of hired farm labor for the west north central region (II)

1936-1939	Constant term		d^{a}	R^{2b}
Model 1				
Demand	$Y_1^3 = \underset{(34.69)}{282.13^{**}}$	$-\underset{(.384)}{1.602^{**}}Y_4^3 - \underset{(.5631)}{.1187}\ X_2 - \underset{(.0028)}{.0120^{**}}X_6^3$		.971
Supply	$Y_1^3 =$	$-\underset{(.508)}{.336}\ Y_4^3 + \underset{(.216)}{.892}\ X_3^3$		.943
Model 2				
Demand	$Y_1^3 = 283.13^{*}$	$-\underset{(.384)}{1.602^{**}}Y_4^3 - \underset{(.5631)}{.1187}\ X_2 - \underset{(.0028)}{.0120^{**}}X_6^3$		.971
Supply	$Y_1^3 =$	$\underset{(.428)}{.617^{*}}\ Y_4^3 - \underset{(.361)}{1.617^{**}}X_2 + \underset{(.163)}{.703^{**}}X_3^3$		.969

Table 17. Simultaneous equations models of hired farm labor for the west north central region (II)

1936–1939	Constant term	d[a]	R^2[b]
	Model 3		
Demand	$Y_1^3 = \underset{(38.32)}{282.8^{**}} - \underset{(.562)}{1.491^{**}}Y_4^3 - \underset{(.948)}{.339}\,X_2 - \underset{(.0032)}{.0124^{**}}X_6^3 - \underset{(.202)}{.065}\,X_{10}$		.968
Supply	$Y_1^3 = \underset{(.592)}{1.299^{**}}Y_4^3 - \underset{(.678)}{4.267^{**}}X_2 + \underset{(1.777)}{4.590^{**}}X_8$		.965
	Model 4		
Demand	$Y_1^3 = \underset{(38.04)}{281.56^{**}} - \underset{(.421)}{1.596^{**}}Y_4^3 - \underset{(.614)}{.127}\,X_2 - \underset{(.0030)}{.0119^{**}}X_6^3$		.967
Supply	$Y_1^3 = \underset{(.590)}{1.383^{**}}Y_4^3 - \underset{(.675)}{4.363^{**}}X_2 + \underset{(1.1169)}{4.727^{**}}X_8$		.962

Table 18. Simultaneous equations models of hired farm labor for the west north central region (II)

1936–1939	Constant term		d^{a}	R^{2b}
	Model 5			
Demand	$Y_1^3 = \underset{(35.96)}{287.45^{**}}$	$- \underset{(.237)}{.988^{**}}Y_5^3 - \underset{(.205)}{2.576^{**}}X_2 - \underset{(.0039)}{.0187^{**}}X_6^3$	1.37	.971
Supply	$Y_1^3 = \underset{(9.20)}{36.95^{**}}$	$+ \underset{(.112)}{.429^{**}}Y_5^3 + \underset{(.062)}{.853^{**}}X_3^3$	1.14^{I}	.965
	Model 6			
Demand	$Y_1^3 = 287.45^{**}$	$- \underset{(.237)}{.988^{*}}Y_5^3 - \underset{(.205)}{2.576^{**}}X_2 - \underset{(.0039)}{.0187^{**}}X_6^3$	1.37	.971
Supply	$Y_1^3 =$	$\underset{(.149)}{.214^{*}}\ Y_5^3 - \underset{(.446)}{.903^{**}}X_2 + \underset{(.130)}{.618^{**}}X_3^3$	1.25^{I}	.970

Table 19. Simultaneous equations models of hired farm labor for the west north central region (II)

1936-1939		Constant term					d^a	R^{2b}
				Model 7				
Demand	$Y_1^3 =$	268.8** (34.55)	$-$ 1.089**Y_5^3 (.410)	$-$ 2.387**X_2 (.297)	$-$ .0173**X_6^3 (.004)	+ .205 X_{10} (.280)	1.40	.968
Supply	$Y_1^3 =$	71.48** (25.73)	+ .350**Y_5^3 (.176)	$-$ 2.401**X_2 (.232)		+ 3.504**X_8 (.862)	1.51	.965
				Model 8				
Demand	$Y_1^3 =$	274.51** (36.19)	$-$ .903**Y_5^3 (.238)	$-$ 2.554**X_2 (.213)	$-$ .0175**X_6^3 (.004)		1.47	.968
Supply	$Y_1^3 =$	61.56** (26.02)	$-$ .419**Y_5^3 (.179)	$-$ 2.323**X_2 (.232)		+ 3.706**X_8 (.849)	1.45	.968

Table 20. Demand equations for hired farm labor for the west north central region (II)

Eq. no.	Time period	Constant term	d^a	R^{2b}
1	1939-70	$Y_1^3 = 173.24^{**} - .569^{**}X_{11}^3 - 1.861^{**}X_2$ (24.98) (.297) (.333)	.932	.968
2	1945-70	$Y_1^3 = 190.74^{**} - .711^{**}X_{11}^3 - .803\ X_2 - .010^{**}X_7^3$ (29.33) (.303) (.620) (.0036)	$.98^I$	.979
3	1945-70	$Y_1^3 = 111.03^{**} - .402\ X_{11}^3 + .440^{**}X_3^3 - .0095^{**}X_7^3$ (56.87) (.356) (.219) (.0028)	1.26^I	.981
4	1945-70	$Y_1^3 = 223.64^{**} - .992^{**}X_{11}^3 - 1.063^{**}X_2 - .010^{**}X_6^3$ (31.68) (.312) (.452) (.003)	1.00^I	.982
5	1945-70	$Y_1^3 = 167.75^{**} - .898^{**}X_{11}^3 + .415^{*}X_3 - .010^{**}X_6^3$ (73.85) (.460) (.244) (.003)	1.15^I	.980
6	1945-70	$Y_1^3 = 78.99 - .112\ X_{11}^3 + .468^{**}X_3^3 - .004\ X_6^3 - 1.146^{**}X_6^3$ (72.21) (.494) (.214) (.0038) (.418)	1.34^I	.985

c. Single equation models of the supply of hired farm labor Equations 1 through 4 are similar to those of Table 15. Equation 4, which is a combination of the previous equations, supports the hypothesis that the supply of hired farm labor is a function of the relative wage rate (i.e., farm/nonfarm), the nonfarm wage rate, and the U.S. rate of unemployment; it reacts with a distributed lag. All parameter estimates are shown in Table 21.

d. Summary The conclusions concerning the hired farm labor market in this region are similar with those of the previous region. Models 5 and 6 of Table 18, 7 and 8 of Table 19, and equations 2 through 6 support the hypothesis that the demand for hired farm labor in this region is a function of the relative wage rate, of the value of the stock of farm machinery, and of the time trend. Again "the prices received" variable, though exhibiting the expected sign, does not appear significant (Table 19, model 7). The same models, as well as equation 4 of Table 21, support the hypothesis that the supply of hired farm labor is a function of the relative wage rate, of the U.S. unemployment rate, and of the time trend; it reacts with a distributed lag.

Table 21. Supply equations of hired farm labor for the west north central region (II)

Eq. no.	Time period	Constant term	d^{a}	$R^{2\,b}$
1	1939-70	$Y_1^3 = \underset{(25.82)}{130.96^{**}} - \underset{(.193)}{.0403}\, X_{12}^3 - \underset{(.270)}{2.504^{**}} X_2$	$.66^{c}$	.963
2	1939-70	$Y_1^3 = \underset{(.148)}{.114}\, X_{12}^3 - \underset{(.435)}{.668^{*}} X_2 + \underset{(.145)}{.689^{**}} X_3^3$	1.23^{I}	.980
3	1939-70	$Y_1^3 = \underset{(26.76)}{111.39^{**}} + \underset{(.193)}{.068}\, X_{12}^3 - \underset{(.282)}{2.286^{**}} X_2 + \underset{(.373)}{.709^{**}} X_8$	$.66^{c}$	.968
4	1939-70	$Y_1^3 = \underset{(.148)}{.184}\, X_{12}^3 - \underset{(.420)}{.616^{*}} X_2 + \underset{(.141)}{.651^{**}} X_3^3 + \underset{(.285)}{.509^{**}} X_8$	1.25^{I}	.983

4. Hired farm labor for the north central region

a. Simultaneous equation models of hired farm labor The data concerning the north central region is obtained by pooling the data of the three subregions; similarly, the same hypothesis will be tested. Models 1 through 4 of Tables 22 and 23 are similar with the models 5 through 8 of Tables 24 and 25. The only difference lies in the price of farm labor variable. In the first group the farm wage rate variable Y_4^4 is used, while in the second group the wage rate ratio variable Y_5^4 is used.

(1) Models 5 and 6 These models are the same with models 5 and 6 of the previous two regions. Model 6 is derived from 5 by adding the time trend to the supply. The results in all models concerning the north central region are influenced by the fact that the data of the east north central region is included. For instance, in model 6 all coefficients appear with the expected signs; however, the "wage rate ratio" variable Y_5^4 is not significant. Most of the estimated coefficients, though they are significant, exhibit greater standard errors. All parameter estimates of models 5 and 6 are presented in Table 24.

(2) Models 7 and 8 Model 7 is obtained from model 8 by adding the prices received variable, X_{10}, which appears to be significant for the first time at a 10 percent probability level. All demand coefficients appear significant

with the expected signs. On the supply side, however, the wage rate ratio coefficient appears with a sign opposite than that expected; the U.S. unemployment variable appears with the expected positive coefficient. The results of the ENC region, as well as the results of the whole NC region, reinforce the idea that the supply function of hired farm labor is more complex in more industrialized areas. The not so favorable results concerning the supply function can also be contributed partly to the deterioration in the quality of data at higher aggregation levels. All parameter estimates of models 7 and 8 are presented in Table 25.

b. Single equation models of the demand for hired farm labor The effect of different deflators on the farm machinery variable is shown by equations 2 and 3. The price index of farm machinery is considered as a better deflator for our purpose than the index of prices paid for production expenses because it yields a higher value for the estimated coefficient with a smaller standard error (i.e., .00575 with standard error .00306 instead of .00512 with .00369). In equation 4 the distributed lag hypothesis is made, but the most important explanatory variable (i.e., the farm wage rate) appears as insignificant. All parameter estimates of equations 1, 2, 3, and 4 are presented in Table 26.

Table 22. Simultaneous equations models of hired farm labor for the north central region

		Constant term		d[a]	R^2[b]
			Model 1		
Demand	$Y_1^4 =$	$\underset{(102.8)}{1338.4^{**}}$	$- \underset{(1.214)}{8.496^{**}}Y_4^4 - \underset{(1.744)}{2.112^{*}}\,X_2 - \underset{(.0027)}{.0092^{**}}X_6^4$		.985
Supply	$Y_1^4 =$		$\underset{(.343)}{.709^{**}}Y_4^4 + \underset{(.297)}{1.105^{**}}X_3^4$		.969
			Model 2		
Demand	$Y_1^4 =$	1338.4^{**}	$- 8.496^{**}Y_4^4 - \underset{(1.744)}{2.112^{*}}\,X_2 - \underset{(.0027)}{.0092^{**}}X_6^4$		.985
Supply	$Y_1^4 =$		$\underset{(2.472)}{1.386}\;Y_4^4 - \underset{(1.159)}{5.385^{**}}X_2 + \underset{(.226)}{.758^{**}}X_3^4$		.983

Table 23. Simultaneous equations models of hired farm labor for the north central region

		Constant term					d^{a}	R^{2b}
				Model 3				
Demand	$Y_1^4 =$	1257.7^{**}	$-\ 10.121^{**}Y_4^4$	$+\ 1.446\ X_2$	$-\ .0060^{*}X_6^7$	$+\ 1.288\ X_{10}$		.977
		(136.8)	(2.419)	(4.170)	(.0039)	(.994)		
Supply	$Y_1^4 =$	633.9^{**}	$-\ .623\ Y_4^4$	$+\ 12.906^{**}X_2$		$+\ 12.916^{**}X_8$		.975
		(184.7)	(2.195)	(2.457)		(4.719)		
				Model 4				
Demand	$Y_1^4 =$	1315.7^{**}	$-\ 8.225^{**}Y_4^4$	$-\ 2.473\ X_2$	$-\ .0088^{**}X_6^4$			.976
		(135.8)	(1.607)	(2.284)	(.0034)			
Supply	$Y_1^4 =$	653.9^{**}	$-\ .862\ Y_4^4$	$-\ 12.642^{**}X_2$		$+\ 12.496^{**}X_8$		.973
		(192.9)	(2.292)	(2.562)		(4.857)		

Table 24. Simultaneous equations models of hired farm labor for the north central region

	Constant term		d^{a}	R^{2b}
		Model 5		
Demand	$Y_1^4 = 1411.7^{**}$ (113.2)	$- 5.481^{**}Y_5^4$ (.783) $- 15.933^{**}X_2$ (.734) $- .01788^{**}X_6^4$ (.0036)	1.41	.985
Supply	$Y_1^4 = -129.06^{**}$ (26.98)	$+ 1.509^{**}Y_5^4$ (.357) $+ .918^{**}X_3^4$ (.0419)	1.26	.983
		Model 6		
Demand	$Y_1^4 = 1411.7^{**}$ (113.2)	$- 5.481^{**}Y_5^4$ (.783) $- 15.933^{**}X_2$ (.734) $- .0178^{**}X_6^4$ (.0036)	1.41	.985
Supply	$Y_1^4 =$	$.428\ Y_5^4$ (.763) $- 4.066^{*}\ X_2$ (2.559) $+ .703^{**}X_3^4$ (.141)	1.35	.979

Table 25. Simultaneous equations models of hired farm labor for the north central region

		Constant term						d[a]	R^2[b]
				Model 7					
Demand	$Y_1^4 =$	1250.4** (135.9)	$-$ 6.053**Y_5^4 (1.447)	$-$ 14.637**X_2 (1.087)	$-$ .0140**X_6^4 (.0043)	+ 1.445*X_{10} (1.022)		1.57	.977
Supply	$Y_1^4 =$	615.7** (108.7)	$-$ .249 Y_5^4 (.789)	$-$ 13.884**X_2 (1.031)			+ 13.244**X_8 (3.644)	1.48	.974
				Model 8					
Demand	$Y_1^4 =$	1315.5** (135.8)	$-$ 4.810**Y_5^4 (.940)	$-$ 15.630**X_2 (.891)	$-$ .0154**X_6^4 (.0043)			1.50	.975
Supply	$Y_1^4 =$	622.9** (110.9)	$-$ .303 Y_5^4 (.805)	$-$ 13.946**X_2 (1.047)			+ 13.081**X_8 (3.674)	1.45	.968

Table 26. Demand equations for hired farm labor for the north central region

Eq. no.	Time period	Constant term	d[a]	R^2[b]
1	1939-70	$Y_1^4 = \underset{(87.10)}{1011.0^{**}} - \underset{(1.132)}{5.168^{**}} X_{11}^4 - \underset{(1.239)}{7.034^{**}} X_2$	.67[c]	.981
2	1945-70	$Y_1^4 = \underset{(95.73)}{1021.2^{**}} - \underset{(1.060)}{5.259^{**}} X_{11}^4 - \underset{(2.127)}{6.217^{**}} X_2 - \underset{(.00369)}{.00512^{*}} X_7^4$	1.15[I]	.988
3	1945-70	$Y_1^4 = \underset{(103.4)}{1077.9^{**}} - \underset{(1.092)}{5.727^{**}} X_{11}^4 - \underset{(1.514)}{6.628^{**}} X_2 - \underset{(.00306)}{.00575^{**}} X_6^4$	1.18[I]	.989
4	1945-70	$Y_1^4 = - \underset{(2.249)}{1.265} X_{11}^4 + \underset{(.211)}{.832^{**}} X_3^4 - \underset{(.0031)}{.00684^{**}} X_6^4$	1.23[I]	.987

c. Single equation models of the supply of hired farm labor   Equation 4 is a combination of equations 2 and 3. The results in equation 4 support the hypothesis that the supply of hired farm labor reacts with a distributed lag and depends on the U.S. level of unemployment. All parameter estimates of equations 1, 2, 3, and 4 are presented in Table 27.

d. Summary   In all three subregions (i.e., ENC, WNC_{I}, WNC_{II}), and in the north central region as a whole, the results of the empirical analysis support the hypothesis that the demand for hired farm labor is a function of the relative wage rate, of the stock value of farm machinery, and of the time trend used as a technology variable. The results concerning "the prices received variable are inconclusive"; this variable appeared only in one case with a significant coefficient (Table 25, model 7), while in all other cases appeared to be insignificant but with the expected positive sign.

For the two subregions (i.e., WNC_{I} and WNC_{II}), as well as for the whole north central region, the results support the hypothesis that the supply of hired farm labor is a function of the relative wage rate, of a time trend, and of the U.S. unemployment rate; it reacts with a distributed lag. In the east north central region where the conditions are more complex the U.S. unemployment rate does not appear

Table 27. Supply equations of hired farm labor for the north central region

Eq. no.	Time period	Constant term		d[a]	R^2[b]
1	1939-70	$Y_1^4 = 781.92^{**}$ (128.24)	$-1.328\ X_{12}^4 - 13.958\ X_2$ (1.019) (1.433)	.50[c]	.968
2	1939-70	$Y_1^4 =$	$1.380^{**} X_{12}^4 + .688\ X_2 + .912\ X_3^4$ (.745) (2.327) (.134)	1.18[I]	.988
3	1939-70	$Y_1^4 = 640.28^{**}$ (116.76)	$-\ .497\ X_{12}^4 - 12.274^{**} X_2 + 5.271\ X_8$ (.901) (1.315) (1.544)	.49[c]	.978
4	1939-70	$Y_1^4 =$	$1.347^{**} X_{12}^4 - .564\ X_2 + .794^{**} X_3^4 + 2.009^{*} X_8$ (.724) (2.392) (.150) (1.251)	1.10[I]	.989

significant.

It should be noted that the results of the analysis deteriorate as we move to a less homogeneous region from a production point of view. This can be attributed to a number of reasons, particularly, that the model becomes too simple to deal with the complex relationships in more industrialized regions, and that the quality of data deteriorates at higher levels of aggregation.

5. Demand and supply elasticities of hired farm labor

The price elasticity of demand (supply) shows the responsiveness of the demand for (supply of) hired farm labor to a change in the relative wage rate.

Table 28 shows estimated demand and supply elasticities for the four production regions, taken at the mean. Since it has been hypothesized that only the supply function reacts with a distributed lag, long run elasticities have been estimated only for the supply.

The elasticity of demand with respect to the value of the stock of farm machinery denotes the responsiveness of the demand for hired farm labor to a change in the value of the stock of farm machinery. The price elasticities of demand range from .815 to 1.430. The short run price elasticities of supply range from .294 to .444. The elasticities in Table 28 show that the demand for hired farm labor appears rather elastic, showing a greater degree of elasticity in the ENC region. The short run price elasticity of supply shows that the supply of hired farm labor is inelastic in the short run. In the long run, however, it becomes considerably more elastic ranging from .770 to .929.[1] The short run elasticities of demand with respect to the stock value of the farm machinery variable range from .200 to .571. These low elasticities of demand show that in the short run the substitution of machinery capital for labor is very limited.

6. Implications

In the preceding analysis there were two proxies which were tested as indicators of the price of farm labor. The first proxy was the farm wage rate, and the second was the ratio of the farm wage rate to the wage rate in manufacturing. In all regions the demand for hired farm labor was found to be responsive to changes in the farm wage rate. However, the supply function did not behave in the same way. In the ENC region the parameter estimate of the farm wage rate in all models which were tested appeared with a

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[1]The value of 4.805 for the long run supply elasticity for the whole north central region is viewed with scepticism since the adjustment coefficient appears unusually small. No long run supply elasticity was estimated for the ENC region because the model shows a negative coefficient of adjustment.

Table 28. Short and long run elasticities of the demand for and supply of hired farm labor estimated at the mean

	$1-\gamma$	Adjust. coeff. γ	Quant. f. labor $\bar{Y}_1$	Index of w. rate $\bar{Y}_5$	$\frac{dY_1}{dY_5}$
Table 6, Model 7, Demand, E.N.C.	--	--	181	88.25	2.877
Table 6, Model 7, Supply, E.N.C.	--	--	181	82.25	.669
Table 12, Model 6, Demand, W.N.C.(I)	--	--	125.2	109.54	.933
Table 12, Model 6, Supply, W.N.C.(I)	.522	.478	125.2	109.54	.508
Table 18, Model 6, Demand, W.N.C.(II)	--	--	80	110.01	.988
Table 18, Model 6 Supply, W.N.C.(II)	.618	.382	80	110.01	.214
Table 24, Model 5, Demand, N.C.	--	--	386.3	100.69	5.481
Table 24, Model 5, Supply, N.C.	.918	.082	386.3	100.69	1.509

$1-\gamma$ = coefficient of the lagged endogenous variable
γ = coefficient of adjustment

$\frac{\bar{Y}_5}{\bar{Y}_1}$	S. run elast. e_{SR}	L. run elast. e_{LR}	F. mach. value $\bar{X}_6$	$\frac{dY_1}{dX_6}$	$\frac{\bar{X}_6}{\bar{Y}_1}$	S. run elast. e_{SR}
.488	1.410	--	4016.5	.009	22.19	.200
.488	.326	--	--	--	--	--
.874	.815	--	2906.6	.0246	23.21	.571
.874	.444	.929	--	--	--	--
1.375	1.358	--	2680.9	.0187	33.51	.626
1.375	.294	.770	--	--	--	--
.261	1.430	--	9604.0	.0178	24.86	.442
.261	.394	4.805	--	--	--	--

negative or insignificant coefficient; while in WNC_I, WNC_{II}, and NC regions the results concerning the supply of hired farm labor were slightly better. The introduction of the relative farm wage rate improved the results considerably in all regions, especially on the supply side. One possible explanation of this fact is that farm operators will demand more hired farm labor when its price is low in a relative or in an absolute sense, but that hired farm workers are willing to supply more labor only if the wages that they receive have been improved in relation to the nonfarm wages.

Although no distributed lag model was hypothesized for the demand for hired farm labor, it is expected that its elasticity will increase in the long run. The high long run elasticity coefficient for the supply in the NC region implies that the elasticity of demand for hired farm labor is higher in more industrialized areas. The results of the empirical analysis concerning this region can be interpreted in the following way.

In the short run: A shift of the demand for hired farm labor to the left due to technological innovations will cause a minor reduction in farm employment and a major reduction in the farm wage rates. The overall effect will be negative in relation to farm wages and incomes. In order to prevent this drastic fall in wages, the supply curve must shift to the left. This would happen if favorable conditions prevailed in the economy as a whole. One of the national economic indicators which has been incorporated in the supply function is the rate of unemployment. A reduction in the U.S. rate of unemployment will cause the supply curve to shift to the left. It is also expected that the various educational programs will increase the skills of the farm labor force, thus making it more suitable for nonfarm work, and will improve the information concerning off farm employment opportunities. This will cause the supply curve to shift to the left. The combined effect of the forementioned supply shifters is expected to be expressed through the time trend variable which appears significant in all regions.

In the long run: Since the results concerning the north central region support the hypothesis that the supply of hired farm labor is elastic in the long run, the overall impact caused by a shift of the demand curve to the left will be more on the farm employment level than on the farm wage rate. If we assume that farm prices and total farm output remain constant, a drastic drop in hired farm employment will have a positive effect in increasing the per capita farm income. Furthermore, a simultaneous shift of the supply curve to the left will improve the income situation of hired farm workers. It is also expected that the various programs which increase the skills and the educational level of the hired farm workers will tend to shorten the period needed to adjust to new economic conditions. This will be reflected in the distributed lag models through an increase in the adjustment coefficient over time. A shorter period of adjustment would imply improved living conditions for the hired farm labor force.

The positive but insignificant coefficient of "the index of prices received" variable implies that farm operators view a rise or a drop in farm prices as a short run phenomenon; therefore, it is expected that farm operators and their family members would rather intensify their work than hire additional farm workers in case of a rise in the price of farm products. The results of the subsequent analysis of the family farm labor market corroborate this interpretation.

The short run cross elasticities of demand for hired farm labor with respect to the value of the stock of farm machinery and equipment imply that the response of the demand for hired farm labor to changes of this variable is low. The results also show that the price index of farm machinery is a better deflator than the index of prices paid for farm products.

Finally, the two statistical procedures (i.e., the simultaneous equation estimation and single equation estimation) which were employed in the empirical analysis yield similar results.

C. Family Farm Labor

1. Family farm labor for the east north central region

a. Simultaneous equation models of family farm labor

The hypothesis we are going to test concerning the family farm labor is similar with the one concerning the hired farm labor. However, a different proxy was tried as the price of family farm labor. The net farm income per family member was considered as the most appropriate variable for this purpose; but since state data concerning net farm income are not reported earlier than 1949, and since gross farm income is highly correlated to net farm income, a proxy consisting of the gross per capita income was used.

(1) Models 1 and 2   Model 2 is derived from model 1 by including in the supply function the time trend. The demand for family farm labor is specified as being a function of the gross per capita farm income, the stock value of farm machinery, and a time trend. The supply is considered to be a function of gross per capita income and of a time trend; in addition, it is assumed that it reacts with a distributed lag. All coefficients concerning the demand appear with the expected sign and are significant

except for the coefficient for the time trend. The supply coefficients appear significant except for the price variable, which appears with the opposite sign than expected. All parameter estimates of models 1 and 2 are presented in Table 29.

(2) Models 3 and 4 Model 3 results from model 4 by including in the demand the "prices received" variable, X_{10}, which is significant and has the expected sign. The time trend and the farm machinery variable appear with the expected sign but are not significant, while the "per capita income" variable appears negative as expected. On the supply side the U.S. unemployment rate variable appears with an insignificant coefficient, and the "per capita income" variable appears with the opposite sign. All parameter estimates of models 3 and 4 are presented in Table 30.

Tables 31, 32 and 33 contain basically the same models as Tables 29 and 30. The only difference lies in the use of the relative wage rate (i.e., variable Y_5^1) as a proxy for the price of family farm labor. The results are slightly improved in model 5, where the wage rate coefficient of the supply function appears for the first time with a positive sign.

Table 29. Simultaneous equations models of family farm labor for the east north central region

	Constant term	d^{a}	R^{2b}
	Model 1		
Demand	$Y_2^1 = \underset{(140.6)}{2189.7^{**}} - \underset{(.077)}{.406^{**}}Y_6^1 - \underset{(6.868)}{1.453}\ X_2 - \underset{(.0265)}{.0475^{**}}X_6^1$	2.52	.982
Supply	$Y_2^1 = - \underset{(1.352)}{.500}\ Y_6^1 + \underset{(.297)}{.931^{**}}X_4^1$	1.55	.971
	Model 2		
Demand	$Y_2^1 = \underset{(140.6)}{2189.7^{**}} - \underset{(.077)}{.406^{**}}Y_6^1 - \underset{(6.868)}{1.453}\ X_2 - \underset{(.0265)}{.0475^{**}}X_6^1$	2.52	.982
Supply	$Y_2^1 = \underset{(548.0)}{971.4^{**}} - \underset{(.109)}{.104}\ Y_6^1 - \underset{(2.896)}{10.481^{**}}X_2 + \underset{(.268)}{.482^{**}}X_4^1$	2.50	.974

Table 30. Simultaneous equations models of family farm labor for the east north central region

		Constant term					d^a	R^{2b}
				Model 3				
Demand	$Y_2^1 =$	1187.3**	$-.378^{**}Y_6^1$	$-2.717\ X_2$	$-.0149\ X_6^1$	$+5.586^{**}X_{10}$	1.61	.972
		(345.6)	(.120)	(13.472)	(.0273)	(2.859)		
Supply	$Y_2^1 =$	1872.1	$-.219^{**}Y_6^1$	$-17.159^{**}X_2$		$+1.473\ X_8$	1.07	.967
		(98.1)	(.062)	(4.257)		(9.946)		
				Model 4				
Demand	$Y_2^1 =$	1882.6**	$-.232^{**}Y_6^1$	$-16.62\ X_2$	$-.0041\ X_6^1$		1.31	.969
		(141.5)	(.076)	(6.862)	(.0282)			
Supply	$Y_2^1 =$	1912.6**	$-.246^{**}Y_6^1$	$-15.337\ X_2$		$-1.362\ X_8$	1.30	.962
		(94.11)	(.060)	(4.092)		(9.433)		

Table 31. Simultaneous equations models of family farm labor for the east north central region

	Constant term		d^{a}	R^{2b}
		Model 5		
Demand	$Y_2^1 = \underset{(211.8)}{2574.7^{**}}$	$- \underset{(1.732)}{9.153^{**}} Y_5^1 - \underset{(1.554)}{34.600^{**}} X_2 - \underset{(.01957)}{.00215} X_6^1$	2.51	.974
Supply	$Y_2^1 = \underset{(97.02)}{-367.09^{**}}$	$+ \underset{(1.065)}{3.531^{**}} Y_5^1 + \underset{(.032)}{1.016^{**}} X_4^1$	2.31	.970
		Model 6		
Demand	$Y_2^1 = \underset{(211.8)}{2574.7^{**}}$	$- \underset{(1.732)}{9.153^{**}} Y_5^1 - \underset{(1.554)}{34.60^{**}} X_2 - \underset{(.01957)}{.00125} X_6^1$	2.51	.974
Supply	$Y_2^1 =$	$- \underset{(8.526)}{8.086} Y_5^1 - \underset{(23.416)}{32.150^{*}} X_2 + \underset{(.686)}{.755} X_4^1$	2.40	.965

Table 32. Simultaneous equations models of family farm labor for the east north central region

		Constant term					d[a]	R^2[b]
				Model 7				
Demand	$Y_2^1 =$	1994.7^{**} (306.6)	$-9.247^{**}Y_5^1$ (2.952)	$-30.383^{**}X_2$ (3.854)	$+.0305\ X_6^1$ (.0252)	$+3.504^{*}X_{10}$ (2.364)	1.61	.973
Supply	$Y_2^1 =$	2535.1^{**} (258.8)	$-8.580^{**}Y_5^1$ (2.242)	$-34.280^{**}X_2$ (1.442)		$-6.250\ X_8$ (10.785)	1.18	.964
				Model 8				
Demand	$Y_2^1 =$	2276.2^{**} (265.8)	$-6.676^{**}Y_5^1$ (2.173)	$-35.219^{**}X_2$ (1.968)	$+.0182\ X_6^1$ (.0247)		1.31	.968
Supply	$Y_2^1 =$	2583.6^{**} (252.8)	$-9.005^{**}Y_5^1$ (1.401)	$-34.42^{**}X_2$ (1.401)		$-7.732\ X_8$ (10.500)	1.30	.946

Table 33. Simultaneous equations models of family farm labor for the east north central region

	Constant term	d[a]	R^2[b]
	Model 9		
Demand	$Y_2^1 = \underset{(122.8)}{2557.5^{**}} - \underset{(1.200)}{9.033^{**}}Y_5^1 - \underset{(1.074)}{34.732^{**}}X_2$	2.60	
Supply	$Y_2^1 = \underset{(95.54)}{-382.1^{**}} + \underset{(1.050)}{3.708^{**}}Y_5^1 + \underset{(.031)}{1.015^{**}}X_4^1$	2.40	

b. Summary Considering the more complex conditions of the family farm labor market in the east north central region, the inclusion of a variable expressing nonfarm income returns in the model, either alone or as a relative income ratio, is expected to improve the results, particularly on the supply side. The prices received variable appears significant and positive, while the results concerning the farm machinery variable are inconclusive since its estimated coefficient appears with either a negative or a positive sign. The same conclusion holds for the U.S. unemployment rate. In model 9 of Table 33, when the farm machinery variable was not included in the demand function, the coefficients of the remaining variables in both the demand and the supply equations appear as expected; however, the lagged endogenous variable on the supply side exhibits a coefficient larger than one, implying a movement away from equilibrium which is not considered as realistic.

2. Family farm labor for the west north central region I

a. Simultaneous equation models of family farm labor

(1) Models 1 and 2 Models 1 and 2 are similar with models 1 and 2 of the ENC region. The results, however, are much better in this region. All coefficients in model 2 are significant and exhibit the expected signs.

Furthermore, they support the hypothesis that the demand for family farm labor is a function of the per capita gross farm income, the stock value of farm machinery, and the time trend; that the supply is a function of the per capita gross farm income and the time trend, and that it reacts with a distributed lag. All parameter estimates of models 1 and 2 are presented in Table 34.

(2) Model 3 The estimated coefficients support the hypothesis that the demand for hired farm labor is a function of all variables mentioned in model 2, and of the "prices received for farm products" variable. The distributed lag hypothesis has been relaxed, and the U.S. unemployment rate which has been included in the supply function is significant exhibiting the expected positive sign. The estimated parameters of model 3 are presented in Table 35.

Tables 36 and 37 include the models 5, 6, 7, and 8 which are similar with models 1, 2, 3, and 4. They only differ in the price of family farm labor variable. The second group includes the relative wage rate instead of the gross per capita farm income. All variables, excluding the "prices received", appear with significant coefficients and expected signs.

Table 34. Simultaneous equations models of family farm labor for the west north central region (I)

1936–1939	Constant term	d[a]	R^2[b]
	Model 1		
Demand	$Y_2^2 = \underset{(60.44)}{1425.2^{**}} - \underset{(.0262)}{.1000^{**}}Y_6^2 - \underset{(3.321)}{7.337^{**}}X_2 - \underset{(.0189)}{.0883^{**}}X_6^2$	1.23[I]	.992
Supply	$Y_2^2 = \underset{(104.6)}{-121.3} - \underset{(.0185)}{.0153}\,Y_6^2 + \underset{(.073)}{1.080^{**}}X_4^2$	.54[c]	.823
	Model 2		
Demand	$Y_2^2 = \underset{(60.44)}{1452.2} - \underset{(.0262)}{.1000^{**}}Y_6^2 - \underset{(3.321)}{7.337^{**}}X_2 - \underset{(.0189)}{.0883^{**}}X_6^2$	1.23[I]	.992
Supply	$Y_2^2 = \underset{(140.28)}{505.54^{**}} + \underset{(.0126)}{.0241^{**}}Y_6^2 - \underset{(2.353)}{12.187^{**}}X_2 + \underset{(.115)}{.540^{**}}X_4^2$	1.14[I]	.984

Table 35. Simultaneous equations models of family farm labor for the west north central region (I)

	Constant term					d^{a}	$R^{2\,b}$
				Model 3			
Demand	$Y_2^2 = 1153.8^{**}$	$-\ .1154^{**}Y_6^2$	$-\ 3.669\ X_2$	$-\ .0727^{**}X_6^2$	$+\ 1.815^{*}X_{10}$	1.16^{I}	.990
	(143.28)	(.0442)	(6.557)	(.0191)	(1.273)		
Supply	$Y_2^2 = 1063.4^{**}$	$+\ .0415^{**}Y_6^2$	$-\ 25.120^{**}X_2$		$+\ 13.078^{**}X_8$	1.10^{I}	.987
	(29.87)	(.0151)	(1.292)		(3.350)		
				Model 4			
Demand	$Y_2^2 = 1370.4^{**}$	$-\ .0754^{**}Y_6^2$	$-\ 10.365^{**}X_2$	$-\ .0726^{**}X_6^2$			.991
	(58.51)	(.0251)	(3.211)	(.0187)			
Supply	$Y_2^2 = 1062.1^{**}$	$+\ .0423^{**}Y_6^2$	$-\ 25.178^{**}X_2$		$+\ 13.166^{**}X_8$	1.10^{I}	.985
	(30.60)	(.0156)	(1.326)		(3.389)		

Table 36. Simultaneous equations models for family farm labor for the west north central region (I)

	Constant term					d[a]	R^2[b]
				Model 5			
Demand	$Y_2^2 =$ 1726.6**	$- 3.214^{**}Y_5^2$	$- 21.826^{**}X_2$	$- .0706^{**}X_6^2$		1.23[I]	.992
	(139.1)	(.842)	(.969)	(.0149)			
Supply	$Y_2^2 =$ −129.44	$+ 1.931^{**}Y_5^2$			$+ .872^{**}X_4^2$	.94[C]	.989
	(28.35)	(.465)			(.043)		
				Model 6			
Demand	$Y_2^2 =$ 1726.6**	$- 3.214^{**}Y_5^2$	$- 21.826^{**}X_2$	$- .0706^{**}X_6^2$		1.23[I]	.992
	(139.1)	(.842)	(.969)	(.0149)			
Supply	$Y_2^2 =$ 348.7**	$+ 1.031^{**}Y_5^2$	$- 7.853^{**}X_2$		$+ .574^{**}X_4^2$	1.20[I]	.984
	(187.4)	(.542)	(3.050)		(.121)		

Table 37. Simultaneous equations models of family farm labor for the west north central region (I)

	Constant term	d^a	$R^{2\,b}$
	Model 7		
Demand	$Y_2^2 = \underset{(156.8)}{1637.5^{**}} - \underset{(1.323)}{3.459^{**}}Y_5^2 - \underset{(1.127)}{21.225^{**}}X_2 - \underset{(.0168)}{.0631^{*}}X_6^2 + \underset{(.967)}{.785}\ X_{10}$	1.14^{I}	.990
Supply	$Y_2^2 = \underset{(108.1)}{840.9^{**}} + \underset{(.691)}{1.903^{**}}Y_5^2 - \underset{(1.221)}{18.701^{**}}X_2 + \underset{(3.576)}{14.148^{**}}X_8$	1.13^{I}	.990
	Model 8		
Demand	$Y_2^2 = \underset{(154.7)}{1663.8^{**}} - \underset{(.937)}{2.813^{**}}Y_5^2 - \underset{(1.063)}{21.555^{**}}X_2 - \underset{(.0165)}{.0648^{**}}X_6^2$	1.10^{I}	.991
Supply	$Y_2^2 = \underset{(109.0)}{842.5^{**}} + \underset{(.698)}{1.893^{**}}Y_5^2 - \underset{(1.231)}{18.717^{**}}X_2 + \underset{(3.596)}{14.115^{**}}X_8$	1.10^{I}	.990

b. Summary Models 2, 3, 6, and 7 support the hypothesis that the demand for family farm labor is a function of gross per capita farm income, the stock value of farm machinery, and the index of prices received for farm products; and that the supply of family farm labor is a function of the gross per capita farm income, the time trend, and the U.S. unemployment rate. Although the distributed lag assumption is supported by models 2 and 6; another distributed lag model, which will incorporate the U.S. unemployment variable, must be tested.

3. Simultaneous equation models of family farm labor for the west north central region II

a. Tables 38, 39, 40, and 41 Models 1 through 8 are the same as models 1 through 8 of the previous region with respect to the structure of the demand for and supply of family farm labor. The results are also similar due to the fact that both regions are more homogeneous from a production point of view than is the east north central region. The Durbin-Watson statistic in most of the equations appears higher than before, and it is used as an indicator that there is no serial correlation among the residuals. For the previous (WNC_I) region, in most equations the test was inconclusive. Models 2, 3, 6, and 7 support the hypothesis that the demand for family farm labor is a function of gross per capita farm income, the

Table 38. Simultaneous equations models of family farm labor for the west north central region (II)

	Constant term	d[a]	R^2[b]
	Model 1		
Demand	$Y_2^3 = \underset{(37.91)}{885.8^{**}} - \underset{(.0131)}{.0529^{**}}Y_6^3 - \underset{(2.805)}{1.780}\,X_2 - \underset{(.0168)}{.0790^{**}}X_6^3$	1.77	.996
Supply	$Y_2^3 = \underset{(62.76)}{69.66^{*}} + \underset{(.0063)}{.0063}\,Y_6^3 + \underset{(.621)}{1.078^{**}}X_4^3$	.50[c]	.985
	Model 2		
Demand	$Y_2^3 = \underset{(37.91)}{885.8^{**}} - \underset{(.0131)}{.0529^{**}}Y_6^3 - \underset{(2.805)}{1.780}\,X_2 - \underset{(.0168)}{.0790^{**}}X_6^3$	1.77	.996
Supply	$Y_2^3 = \underset{(68.81)}{388.7^{**}} + \underset{(.0035)}{.0096^{**}}Y_6^3 - \underset{(1.269)}{9.206^{**}}X_2 + \underset{(.094)}{.441^{**}}X_4^3$	1.70	.994

Table 39. Simultaneous equations models of family farm labor for the west north central region (II)

	Constant term	d^a	R^{2b}
	Model 3		
Demand	$Y_2^3 = \underset{(113.1)}{437.8^{**}} - \underset{(.0180)}{.0540^{**}}Y_6^3 - \underset{(4.813)}{1.310}\,X_2 - \underset{(.0119)}{.0436^{**}}X_6^3 + \underset{(.970)}{2.732^{**}}X_{10}$	1.20[I]	.994
Supply	$Y_2^3 = \underset{(10.15)}{681.3^{**}} + \underset{(.0037)}{.0120^{**}}Y_6^3 - \underset{(.531)}{15.664^{**}}X_2 + \underset{(1.571)}{5.881^{**}}X_8$	1.15[I]	.992
	Model 4		
Demand	$Y_2^3 = \underset{(22.97)}{786.2^{**}} - \underset{(.0075)}{.0179^{**}}Y_6^3 - \underset{(1.661)}{9.206^{**}}X_2 - \underset{(.0107)}{.0355^{**}}X_6^3$	1.09[I]	.994
Supply	$Y_2^3 = \underset{(11.24)}{682.9^{**}} + \underset{(.0042)}{.0112^{**}}Y_6^3 - \underset{(.600)}{15.561^{**}}X_2 + 5.645^{**}X_8$	1.10[I]	.991

Table 40. Simultaneous equations models of family farm labor for the west north central region (II)

		Constant term					d[a]	R^{2}[b]
				Model 5				
Demand	$Y_2^3 =$	1162.3^{**}	$-\ 2.829^{**}Y_5^3$	$-\ 13.740^{**}X_2$	$-\ .0517^{**}X_6^3$		1.77	.996
		(105.9)	(.700)	(.417)	(.0104)			
Supply	$Y_2^3 =$	-131.8^{**}	$+\ 1.602^{**}Y_5^3$			$+\ .882^{**}X_4^3$	.97[c]	.992
		(25.02)	(.338)			(.035)		
				Model 6				
Demand	$Y_2^3 =$	1162.3^{**}	$-\ 2.829^{**}Y_5^3$	$-\ 13.740^{**}X_2$	$-\ .0517^{**}X_6^3$		1.77	.996
			(.700)	(.417)	(.0104)			
Supply	$Y_2^3 =$	251.5^{**}	$+\ .967^{**}Y_5^3$	$-\ 6.327^{**}X_2$		$+\ .488^{**}X_4^3$	1.70	.994
		(94.58)	(.312)	(1.530)		(.099)		

Table 41. Simultaneous equations models of family farm labor for the west north central region (II)

	Constant term	d^{a}	$R^{2\,b}$
	Model 7		
Demand	$Y_2^3 = \underset{(71.48)}{882.7^{**}} - \underset{(.849)}{2.545^{**}}X_5^3 - \underset{(.614)}{12.162^{**}}X_2 - \underset{(.0083)}{.0286^{**}}X_6^3 + \underset{(.578)}{1.436^{**}}X_{10}$	1.20^{I}	.994
Supply	$Y_2^3 = \underset{(51.87)}{543.9^{**}} + \underset{(.356)}{1.119^{**}}X_5^3 - \underset{(.467)}{12.835^{**}}X_2 + \underset{(1.737)}{6.623^{**}}X_8$	1.12^{I}	.993
	Model 8		
Demand	$Y_2^3 = \underset{(79.02)}{922.2^{**}} - \underset{(.520)}{1.238^{**}}X_5^3 - \underset{(.466)}{13.332^{**}}X_2 - \underset{(.0088)}{.0301^{**}}X_6^3$	1.09^{I}	.991
Supply	$Y_2^3 = \underset{(56.82)}{556.6^{**}} + \underset{(.390)}{1.030^{**}}X_5^3 - \underset{(.507)}{12.936^{**}}X_2 + \underset{(1.854)}{6.363^{**}}X_8$	1.10^{I}	.989

stock value of farm machinery, and the index of prices received for farm products; and that the supply is a function of the gross per capita farm income, the time trend, and the U.S. unemployment rate.

4. <u>Simultaneous equation models of family farm labor for the north central region</u>

The models concerning the family farm labor market are shown in Tables 42, 43, 44, and 45. The hypothesis which has been tested is the same as in the previous regions. Models 2, 3, 6, and 7 support the hypothesis that the demand for family farm labor is a function of the gross per capita farm income, the stock value of farm machinery, and the index of prices received for farm products. The time trend appears with the expected negative sign, but it is not significant in all cases. The results concerning the supply are not so good. In models 2, 3, and 4 the gross per capita farm income appears with a negative sign, the time trend is significant with the expected negative sign, and the U.S. unemployment rate is significant as well with its positive sign. The same thing can be said for models 6, 7, and 8 (Tables 44, 45) which have as a price of family farm labor the relative wage rate. However, the significant coefficient of the farm machinery variable in the demand function of model 3 compared with its insignificant value in model 7, is an indicator that the demand and supply

Table 42. Simultaneous equations models of family farm labor for the north central region

		Constant term					d[a]	R^2[b]
				Model 1				
Demand	$Y_2^4 =$	4428.2^{**}	$- .470^{**}Y_6^4$	$- 12.779^{**}X_2$	$- .0702^{**}X_6^4$		2.09	.992
		(176.2)	(.080)	(9.986)	(.0170)			
Supply	$Y_2^4 =$	-603.93^{*}	$+ .0837\ Y_6^4$			$+ 1.143^{**}X_4^4$	1.02[I]	.984
		(408.2)	(.0720)			(.0958)		
				Model 2				
Demand	$Y_2^4 =$	4428.2^{**}	$- .470^{**}Y_6^4$	$- 12.779^{**}X_2$	$- .0702^{**}X_6^4$		2.09	.992
		(176.2)	(.080)	(9.986)	(.0170)			
Supply	$Y_2^4 =$	1515.4^{**}	$- .0079\ Y_6^4$	$- 29.414^{**}X_2$		$+ .575\ X_4^4$	2.00	.991
		(538.6)	(.0551)	(6.281)		(.139)		

Table 43. Simultaneous equations models of family farm labor for the north central region

		Constant term					d[a]	R^2[b]
				Model 3				
Demand	$Y_2^4 =$	2622.5**	$-.521^{**}Y_6^4$	$-5.664\ X_2$	$-.0338^{**}X_6^4$	$+11.361^{**}X_{10}$	1.48	.987
		(540.4)	(.153)	(23.44)	(.0191)	(4.693)		
Supply	$Y_2^4 =$	3509.4**	$-.0710\ Y_6^4$	$-61.305^{**}X_2$		$+25.443^{**}X_8$	1.08[I]	.984
		(105.7)	(.0557)	(4.923)		(12.748)		
				Model 4				
Demand	$Y_2^4 =$	4028.1**	$-.283^{**}Y_6^4$	$-35.732^{**}X_2$	$-.0346^{**}X_6^4$		1.18[I]	.986
		(195.0)	(.086)	(10.994)	(.0194)			
Supply	$Y_2^4 =$	3549.1**	$-.0952^{*}Y_6^4$	$-59.311^{**}X_2$		$+22.350^{**}X_8$	1.18[I]	.978
		(105.8)	(.0563)	(4.950)		(12.559)		

Table 44. Simultaneous equations models of family farm labor for the north central region

		Constant term					d[a]	R^2[b]
				Model 5				
Demand	$Y_2^4 =$	6028.5^{**}	$-\ 18.154^{**}Y_5^4$	$-\ 78.563^{**}X_2$	$-\ .0454^{**}X_6^4$		2.09	.992
		(442.8)	(3.069)	(2.623)	(.0134)			
Supply	$Y_2^4 =$	-490.22^{**}	$+\ 5.987^{**}Y_5^4$			$+\ .9292^{**}X_4^4$	1.91	.990
		(99.67)	(1.453)			(.0335)		
				Model 6				
Demand	$Y_2^4 =$	6028.5^{**}	$-\ 18.154^{**}Y_5^4$	$-\ 78.563^{**}X_2$	$-\ .0454^{**}X_6^4$		2.09	.992
			(3.069)	(2.623)	(.0134)			
Supply	$Y_2^4 =$	1583.1^{*}	$-\ .468\ Y_5^4$	$-30.956^{**}X_2$		$+\ .570^{**}X_4^4$	2.00	.989
		(959.5)	(3.263)	(14.259)		(.168)		

Table 45. Simultaneous equations models of family farm labor for the north central region

	Constant term	d[a]	R^2[b]
	Model 7		
Demand	$Y_2^4 = 4758.9^{**} - 17.928^{**}Y_5^4 - 70.555^{**}X_2 - .0148\ X_6^4 + 7.364^{**}X_{10}$	1.48	.987
	(495.6) (5.277) (3.966) (.0159) (3.728)		
Supply	$Y_2^4 = 3966.9^{**} - 4.198^{*}\ Y_5^4 - 72.087^{**}X_2 + 21.657^{**}X_8$	1.10[I]	.985
	(418.7) (3.038) (3.968) (14.033)		
	Model 8		
Demand	$Y_2^4 = 5089.5^{**} - 11.608^{**}Y_5^4 - 75.605^{**}X_2 - .0221^{**}X_6^4$	1.18[I]	.986
	(513.0) (3.549) (3.366) (.0163)		
Supply	$Y_2^4 = 4095.2^{**} - 5.136^{**}Y_5^4 - 73.187^{**}X_2 + 18.782^{*}X_8$	1.15[I]	.982
	(418.8) (3.039) (3.955) (13.879)		

function are better specified if an income proxy is used as the price of family farm labor. Considering the significant improvement of the results in the case of hired farm labor when the relative wage rate variable was used, we can expect to have a better model in the case of family farm labor if a proxy of the relative income (farm vs. nonfarm) would be used. Additionally, one or more variables that will link the farm and the nonfarm labor market are needed in cases where the production regions are not very homogeneous.

5. Demand and supply elasticities of family farm labor

The price elasticity of demand (supply) shows the responsiveness of the demand for (supply of) family farm labor to a change in the relative wage rate. The demand and supply elasticities which were estimated at the mean level are shown in Tables 46 and 47.

The short run elasticities of demand with respect to the wage rate for the four production regions range from .466 in WNC_I region to .804 in the NC region. By comparing Tables 28 and 46 we see that the demand for hired farm labor is more elastic than the demand for family farm labor. This means that in adverse economic conditions the first kind of labor to be laid off is the hired farm labor.

The short run elasticities of supply range from .150 in WNC_I region to .307 in the ENC region. By comparing them with the corresponding elasticities of Table 28, we see that the short run elasticity of supply is considerably smaller in the case of family farm labor. The same conclusion can be derived in the case of the long run elasticities. The higher value of the elasticity of supply in the ENC region can be interpreted as an indicator of the greater mobility of the family farm labor force in more industrialized areas.

The elasticity of the demand for family farm labor with respect to the stock value of farm machinery is much lower than in the case of hired farm labor (see Tables 28 and 46). This means that the farm machinery capital substitutes firstly for hired and secondly for family farm labor.

Table 47 shows short run demand elasticities of family farm labor with respect to "the prices received" variable for the four production regions. The estimated elasticities range from .263 in the WNC_{I} region to .660 in the WNC_{II} region. The higher elasticities with respect to the "prices received" variable can be interpreted as indicating that the demand for family farm labor is more responsive in the short run to changes in the prices received for farm products than to changes in the value of the stock of farm machinery.

Table 46. Short and long run elasticities of the demand for and supply of family farm labor estimated at the mean

	$1-\gamma$	Adjust. coeff. γ	Quant. f. labor $\bar{Y}_2$	Index of w. rate $\bar{Y}_5$	$\frac{dY_2}{dY_5}$
Table 33, Model 9, Demand, E.N.C.	--	--	1064.2	88.25	9.033
Table 33, Model 9, Supply, E.N.C.	--	--	1064.2	88.25	3.708
Table 36, Model 6, Demand, W.N.C.(I)	--	--	757.6	109.54	3.214
Table 36, Model 6, Supply, W.N.C.(I)	.574	.426	757.6	109.54	1.031
Table 40, Model 6, Demand, W.N.C.(II)	--	--	452.4	110.01	2.829
Table 40, Model 6, Supply, W.N.C.(II)	.488	.512	452.4	110.01	.867
Table 44, Model 5, Demand, N.C.	--	--	2272.0	100.69	18.154
Table 44, Model 5, Supply, N.C.	.929	.071	2272.0	100.69	5.987

$1-\gamma$ = coefficient of the lagged endogenous variable
γ = coefficient of adjustment

$\frac{\bar{Y}_5}{\bar{Y}_2}$	S. run elast. e_{SR}	L. run elast. e_{LR}	F. mach. value $\bar{X}_6$	$\frac{dY_2}{dX_6}$	$\frac{\bar{X}_6}{\bar{Y}_2}$	S. run elast. e_{SR}
.0829	.749	--	--	--	--	--
.0829	.307	--	--	--	--	--
.145	.466	--	2906.6	.0706	3.837	.271
.145	.150	.352	--	--	--	--
.243	.687	--	2680.9	.0517	5.926	.306
.243	.211	.432	--	--	--	--
.0443	.804	--	9604.0	.0454	4.227	.192
.0443	.265	3.735	--	--	--	--

Table 47. Short run demand elasticities of family farm labor with respect to the index of prices received, estimated at the mean

	Quant. f. labor $\bar{Y}_2$	Index of prices received $\bar{Y}_{10}$	$\frac{dY_2}{dY_{10}}$	$\frac{\bar{Y}_{10}}{\bar{Y}_2}$	Elast. e
Table 30, Model 3, Demand, E.N.C.	1064.2	109.05	5.586	.1028	.574
Table 35, Model 3, Demand, W.N.C.(I)	757.6	109.05	1.815	.1447	.263
Table 39, Model 3, Demand, W.N.C.(II)	452.4	109.05	2.732	.2415	.660
Table 43, Model 3, Demand, N.C.	2272.0	109.05	11.361	.0480	.545

6. Summary and economic implications

In the case of family farm labor two proxies were used to express its price. The first was the gross per capita farm income and the second, the relative farm wage rate. The demand function appeared to be better specified when the income variable was considered as the price of family farm labor. In all subregions, and in the north central as a whole, the results support the hypothesis that the demand for family farm labor is a function of the gross per capita farm income, the value of the stock of farm machinery, and of the index of prices received. The time trend did not appear significant when the prices received variable was introduced in model 3 of Table 43. It does appear significant, however, in model 7 of Table 45 when the relative farm wage is used as a price proxy. The results concerning the farm machinery variable were inconclusive in the east north central region. The supply of family farm labor appears to be a function of the gross per capita farm income, the U.S. rate of unemployment, and of the time trend. For the ENC region the results concerning the unemployment rate variable are inconclusive. Although one model in each region supports the hypothesis of a distributed lag adjustment for the supply, another one is needed to incorporate all the important demand and supply variables as well as the distributed lag hypothesis. It is expected that when a proxy of the relative income (agricultural versus nonagricultural) is included the results concerning the supply behavior will be significantly improved. The estimated elasticities show that the demand for family farm labor is more elastic than the supply, and that the long run elasticity of supply is higher than the short run elasticity. The lower demand elasticities of the family farm labor in relation to the hired farm labor imply that in adverse economic conditions the hired farm labor will be laid off first.

In the short run: A shift of the supply curve to the left caused by a reduction in the rate of unemployment or by other supply shifters, such as increased skills for nonfarm work or a rising educational level of family farm workers, will have a greater effect in increasing farm wages and incomes and a smaller effect in reducing the farm employment level because the demand for hired farm labor is inelastic in the short run. Likewise, a shift of the demand curve to the right, caused by an increase in the prices received for farm products, will have a greater effect on farm wage rates and incomes than on farm employment.

In the long run: The supply of family farm labor appears elastic in the long run. Thus, a shift of the demand curve to the right, caused by increases in the prices received for farm products, will have a minor effect in increasing farm wage rates and incomes, and a major effect on farm employment. Thus continuous price support programs tend to keep the family labor force in the farm sector and work toward the opposite direction than do the various educational programs which serve the purpose of preparing part of the family labor force for employment in the nonfarm sector.

The time trend which was used as an indicator of technological change was not statistically significant in all models which provided the best explanation of this analysis. Further investigation is required when a more appropriate proxy is used as the price of hired farm labor. If the statistical results were significantly improved, a negative sign would imply that the demand for family farm labor would shift to the left, assuming new technologies are developed in the agricultural sector. Considering the elastic long run supply curve, a shift of the demand to the left would have a major effect on the farm employment level and a minor effect on its price, but a simultaneous shift of the supply curve to the left would offset the decreases in the farm wage rate.

D. Total Farm Labor

1. Simultaneous equation models of total farm labor for the east north central region

The total farm labor is the sum of hired and family farm labor. The family farm labor component is much larger than the hired farm labor component. We have chosen as the price of total farm labor the ratio of the hourly farm wage rate to the hourly wage rate in manufacturing rather than the gross per capita farm income, because the supply function is better specified with the inclusion of the first variable. The hypotheses which will be tested are similar to those concerning the hired and family farm labor.

a. Models 1 and 2 Model 2 of Table 48 is derived from model 1 by including in the supply function the time trend variable. The inclusion of this variable improved the results in relation to the distributed lag hypothesis; that is, the greater than one (i.e., 1.028) coefficient of the lagged endogenous variable X_5^1 becomes .877, but the farm wage rate coefficient of the supply function, although positive, loses its significance. It was expected that the empirical analysis concerning the total farm labor would yield similar results to the analysis of family farm labor, since the latter is its major component; however, by pooling the two categories of farm labor together we obtained results which were different than those of the family labor market. The difference can be observed by comparing models 1 and 2 of Table 48 with models 5 and 6 of Table 31 which have the same specification, the only difference being in the quantity of farm labor. Thus in model 5 of Table 31 the coefficient of the farm machinery variable is negative though insignificant, while in model 1 of Table 48 it appears significant at a 10 percent probability level.

Model 2 of Table 48, though similar to model 6 of Table 31, yields better results. In particular, the farm machinery coefficient is significant at a 10 percent probability level, the coefficient of the relative farm wage rate on the supply side, although insignificant, exhibits the expected sign, the lagged endogenous variable is significant a 10 percent; but the time trend looses its significance. The results of the east north central region, although far from being satisfactory, corroborated the hypothesis that the farm wage rate ratio was a better price proxy for the total farm labor than for the family farm labor.

b. Models 3 and 4 These models can be compared with models 7 and 8 of Table 32. The results concerning the farm machinery variable and the U.S. unemployment rate are similar. Again, model 3 fails to capture the more complex conditions of the farm labor market of the east north central region. Model 3 is derived from model 4 by including in the demand function the prices received variable, which is significant at a 10 percent probability level. The farm machinery variable appears with a negative though insignificant coefficient. The results of models 2 and 3 support the hypothesis that the demand for total farm labor is a function of the relative farm wage rate, the index of prices received, and a time trend. The t-tests concerning the coefficient of farm machinery are inconclusive because in model 2 it is significant while in model 3 it is not. The results concerning the supply are less favorable. The wage rate ratio coefficient is negative in both models.

All parameter estimates of models 1, 2, 3, and 4 are presented in Tables 48 and 49.

2. Simultaneous equation models of total farm labor for the west north central region I

a. Models 1, 2, 3, and 4 Models 1 through 4 are similar with models 5 through 8 in the case of family farm labor of the same region. Models 2 and 3 support the hypothesis that the demand for total farm labor is a function of the relative farm wage rate, the stock value of farm machinery, and of the time trend. The farm machinery variable appears significant in model 3, and the prices received variable exhibits a positive but insignificant coefficient. The supply of total farm labor is a function of the relative

Table 48. Simultaneous equations models of total farm labor for the east north central region

	Constant term				d[a]	R^2[b]
			Model 1			
Demand	$Y_3^1 = 3200.0^{**}$	$- 11.850^{**}Y_5^1$	$- 40.787^{**}X_2$	$- .0219^{*}X_6^1$	2.17	.992
	(149.1)	(1.216)	(1.177)	(.0143)		
Supply	$Y_3^1 = 399.8^{**}$	$+ 3.640^{**}Y_5^1$		$+ 1.028^{**}X_5^1$	2.16	.993
	(68.89)	(.755)		(.019)		
			Model 2			
Demand	$Y_3^1 = 3200.0^{**}$	$- 11.850^{**}Y_5^1$	$- 40.787^{**}X_2$	$- .0219^{*}X_6^1$	2.17	.992
	(149.1)	(1.216)	(1.177)	(.0143)		
Supply	$Y_3^1 =$	$+ 1.546\ Y_5^1$	$- 6.206\ X_2$	$+ .877^{*}X_5^1$	2.15	.991
		(7.962)	(23.486)	(.573)		

Table 49. Simultaneous equations models of total farm labor for the east north central region

		Constant term						d[a]	R^{2}[b]
				Model 3					
Demand	$Y_3^1 =$	2442.8**	$-\ 11.595^{**}Y_5^1$	$-\ 35.778^{**}X_2$	$-\ .0214\ X_6^1$	$+\ 4.261^{*}X_{10}$		1.29^{I}	.976
		(345.7)	(3.327)	(4.345)	(.0284)	(2.665)			
Supply	$Y_3^1 =$	2837.4**	$-\ 8.736^{**}Y_5^1$	$-\ 41.205^{**}X_2$			$-\ 1.014\ X_8$	$.88^{C}$	.973
		(292.2)	(2.532)	(1.629)			(12.181)		
				Model 4					
Demand	$Y_3^1 =$	2785.2**	$-\ 8.407^{**}Y_5^1$	$-\ 41.647^{**}X_2$	$-\ .0064\ X_6^1$			$.98^{C}$	.974
		(300.8)	(2.459)	(2.227)	(.0279)				
Supply	$Y_3^1 =$	2893.1**	$-\ 9.224^{**}Y_5^1$	$-\ 41.367^{**}X_2$			$-\ 2.713\ X_8$	1.01^{I}	.973
		(286.1)	(2.479)	(1.586)			(11.884)		

farm wage rate, the U.S. rate of unemployment, and of a time trend. Model 2 supports the distributed lag hypothesis for the supply function, but another equation which will include the U.S. unemployment variable must be constructed. All parameter estimates are presented in Tables 50 and 51.

3. Simultaneous equation models of total farm labor for the west north central region II

a. Models 1, 2, 3, and 4   Whatever has been said about the hypothesis concerning the total farm labor market of the WNC_I region holds for the WNC_{II} as well. In addition, the prices received variable, which appears significant, must be included in the demand function.

4. Simultaneous equation models of total farm labor for the north central region

The north central region consists of the three aforementioned subregions; the hypothesis which has been tested is the same as in the previous subregions. Model 3 of Table 55 supports the hypothesis that the demand for total farm labor is a function of the relative farm wage rate, of stock value of farm machinery, of the index of prices received for farm products, and of the time trend. However, in the same model the wage rate appears with a negative but insignificant coefficient, the time trend with the expected negative sign, and the U.S. unemployment rate positive and significant.

Only in models 1 and 2 the wage rate ratio appears with the expected positive sign. The results of model 2 support the hypothesis of the distributed lag assumption concerning the supply of total farm labor.

5. Demand and supply elasticities of total farm labor

The demand and supply elasticities which have been estimated at the mean level, are shown in Tables 56 and 57. The short run elasticities of demand, with respect to the relative farm wage rate for the four production regions, range from .504 in WNC_I region, to .882 in the NC region. Total farm labor appears to be more inelastic in the relatively homogeneous WNC_I and WNC_{II} production regions. The short run supply elasticity appears much lower than the short run demand elasticity; its range in the four regions is from .170 in the WNC_I to .280 in the NC. The lagged endogenous variable coefficient appears greater than one in the ENC region, implying a movement away from equilibrium. The long run elasticities of supply in the two west north central regions are low but at least twice as large as the short run elasticities, implying that in the long run the total amount of farm labor supplied is more responsive to wage rate or farm income changes than it is in the short run. The short run elasticities of demand in the four regions with respect to the value of the stock of farm machinery are much lower

Table 50. Simultaneous equations models of total farm labor for the west north central region (I)

		Constant term					d^{a}	R^{2b}
				Model 1				
Demand	$Y_3^2 =$	2078.8^{**}	$- 4.062^{**}Y_5^2$	$- 26.023^{**}X_2$	$- .0898^{**}X_6^2$		1.25^{I}	.992
		(166.6)	(1.009)	(1.151)	(.0178)			
Supply	$Y_3^2 =$	-169.2^{**}	$+ 2.518^{**}Y_5^2$			$+ .859^{**}X_5^2$	$.92^{C}$	.989
		(34.40)	(.555)			(.043)		
				Model 2				
Demand	$Y_3^2 =$	2078.8^{**}	$- 4.062^{**}Y_5^2$	$- 26.023^{**}X_2$	$- .0898^{**}X_6^2$		1.25^{I}	.992
		(166.6)	(1.009)	(1.151)	(.0178)			
Supply	$Y_3^2 =$	398.4^{**}	$+ 1.370^{**}Y_5^2$	$- 9.383^{**}X_2$		$+ .567^{**}X_5^2$	1.23^{I}	.990
		(208.5)	(.642)	(3.411)		(.113)		

Table 51. Simultaneous equations models of total farm labor for the west north central region (I)

		Constant term						d^{a}	$R^{2\,b}$
				Model 3					
Demand	$Y_3^2 =$	2017.3**	$-$ 4.682**Y_5^2	$-$ 25.487**X_2	$-$ .0851**X_6^2	+ 1.004 X_{10}		1.16^{I}	.991
		(176.4)	(1.490)	(1.268)	(.0189)	(1.088)			
Supply	$Y_3^2 =$	942.7**	+ 2.494**Y_5^2	$-$ 22.069**X_2			+ 19.051**X_8	1.14^{I}	.991
		(121.6)	(.778)	(1.374)			(4.023)		
				Model 4					
Demand	$Y_3^2 =$	2051.0**	$-$ 3.857**Y_5^2	$-$ 25.909**X_2	$-$ .0874**X_6^2			1.10^{I}	.992
		(174.2)	(1.055)	(1.197)	(.0186)				
Supply	$Y_3^2 =$	944.3**	+ 2.484**Y_5^2	$-$ 22.085**X_2			+ 19.019**X_8	1.11^{I}	.991
		(122.8)	(.785)	(1.386)			(4.048)		

Table 52. Simultaneous equations models of total farm labor for the west north central region (II)

	Constant term	d^{a}	R^{2b}
	Model 1		
Demand	$Y_3^3 = \underset{(111.5)}{1420.2^{**}} - \underset{(.736)}{3.662^{**}}Y_5^3 - \underset{(.483)}{15.912^{**}}X_2 - \underset{(.0112)}{.0697^{**}}X_6^3$	1.44	.995
Supply	$Y_3^3 = \underset{(28.26)}{-163.9^{**}} - \underset{(.379)}{1.971^{**}}Y_5^3 + \underset{(.034)}{.880^{**}}X_5^3$	.82[c]	.992
	Model 2		
Demand	$Y_3^3 = \underset{(111.5)}{1420.2^{**}} - \underset{(.736)}{3.662^{**}}Y_5^3 - \underset{(.483)}{15.912^{**}}X_2 - \underset{(.0112)}{.0697^{**}}X_6^3$	1.44	.995
Supply	$Y_3^3 = \underset{(101.4)}{229.1^{**}} + \underset{(.359)}{1.152^{**}}Y_5^3 - \underset{(1.616)}{6.413^{**}}X_2 + \underset{(.088)}{.545^{**}}X_5^3$	1.40	.996

Table 53. Simultaneous equations models of total farm labor for the west north central region (II)

		Constant term	d^a	R^{2b}
		Model 3		
Demand	$Y_3^3 =$	$1117.2^{**} - 3.856^{**}Y_5^3 - 13.851^{**}X_2 - .0452^{**}X_6^3 + 2.014^{**}X_{10}$	1.47	.994
		(85.21) (1.012) (.732) (.0098) (.690)		
Supply	$Y_3^3 =$	$584.4^{**} + 1.637^{**}Y_5^3 - 14.763^{**}X_2 + 10.278^{**}X_8$	1.30	.993
		(61.60) (.422) (.554) (2.063)		
		Model 4		
Demand	$Y_3^3 =$	$1172.6^{**} - 2.023^{**}Y_5^3 - 15.491^{**}X_2 - .0473^{**}X_6^3$	1.10	.993
		(94.97) (.625) (.560) (.0105)		
Supply	$Y_3^3 =$	$597.7^{**} + 1.544^{**}Y_5^3 - 14.868^{**}X_2 + 10.006^{**}X_8$	1.09	.990
		(68.3) (.468) (.609) (2.228)		

Table 54. Simultaneous equations models of total farm labor for the north central region

		Constant term					d[a]	R^2[b]
				Model 1				
Demand	$Y_3^4 =$	7412.6**	$- 23.281^{**}Y_5^4$	$- 93.98^{**}X_2$	$- .0653^{**}X_6^4$		1.63	.994
		(434.0)	(3.006)	(2.639)	(.0133)			
Supply	$Y_3^4 =$	-615.3**	$+ 7.384^{**}Y_5^4$			$+ .930^{**}X_5^4$	1.35	.993
		(110.4)				(.028)		
				Model 2				
Demand	$Y_3^4 =$	7412.6**	$- 23.281^{**}Y_5^4$	$- 93.98^{**}X_2$	$- .0653^{**}X_6^4$		1.63	.994
		(434.0)	(3.006)	(2.639)	(.0133)			
Supply	$Y_3^4 =$	1263.5*	$+ 1.424\ Y_5^4$	$- 28.32^{**}X_2$		$+ .658^{**}X_5^4$	1.60	.994
		(912.1)	(3.178)	(13.675)		(.134)		

Table 55. Simultaneous equations models of total farm labor for the north central region

		Constant term					d[a]	R^2[b]
				Model 3				
Demand	$Y_3^4 =$	5902.7** (574.8)	$-$ 23.277**Y_5^4 (6.110)	$-$ 84.332**X_2 (4.595)	$-$ .0289*X_6^4 (.0184)	+ 8.964**X_{10} (4.319)	1.33[I]	.988
Supply	$Y_3^4 =$	4465.9** (481.8)	$-$ 3.477 Y_5^4 (3.495)	$-$ 85.169**X_2 (4.566)		+ 35.237**X_8 (16.146)	.97[C]	.874
				Model 4				
Demand	$Y_3^4 =$	6305.4** (593.7)	$-$ 15.562**Y_5^4 (4.108)	$-$ 90.496**X_2 (3.895)	$-$ .0378**X_6^4 (.0189)		1.03[I]	.878
Supply	$Y_3^4 =$	4604.8** (484.7)	$-$ 4.493 Y_5^4 (3.518)	$-$ 86.361**X_2 (4.577)		+ 32.122**X_8 (16.062)	1.00[I]	.879

Table 56. Short and long run elasticities of demand for and supply of total farm labor estimated at the mean

	$1-\gamma$	Adjust. coeff. γ	Quant. f. labor $\bar{Y}_3$	Index of w. rate $\bar{Y}_5$	$\frac{dY_3}{dY_5}$
Table 48, Model 1, Demand, E.N.C.	--	--	1244	88.25	11.850
Table 48, Model 1, Supply, E.N.C.	--	--	1244	88.25	3.640
Table 50, Model 2, Demand, W.N.C.(I)	--	--	882.2	109.54	4.602
Table 50, Model 2, Supply, W.N.C.(I)	.567	.433	882.2	109.54	1.370
Table 52, Model 2, Demand, W.N.C.(II)	--	--	529.5	110.01	3.662
Table 52, Model 2, Supply, W.N.C.(II)	.545	.455	529.5	110.01	1.152
Table 54, Model 1, Demand, N.C.	--	--	2655.8	100.69	23.281
Table 54, Model 1, Supply, N.C.	.930	.070	2655.8	100.69	7.384

$1-\gamma$ = coefficient of the lagged endogenous variable
γ = coefficient of adjustment

$\frac{\bar{Y}_5}{\bar{Y}_1}$	S. run elast. e_{SR}	L. run elast. e_{LR}	F. mach value $\bar{X}_6$	$\frac{dY_1}{dX_6}$	$\frac{\bar{X}_6}{\bar{Y}_1}$	S. run elast. e_{SR}
.0709	.840	--	4016.5	.0219	3.229	.071
.0709	.258	--	--	--	--	--
.1242	.504	--	2906.6	.0898	3.296	.296
.1242	.170	.393	--	--	--	--
.2078	.761	--	2680.9	.0697	5.063	.353
.2078	.239	.525	--	--	--	--
.0379	.992	--	9604.0	.0653	3.616	.236
.0379	.280	4.00	--	--	--	--

Table 57. Short run demand elasticities of total farm labor with respect to the index of prices received, estimated at the mean

	Quant. f. labor $\bar{Y}_3$	Index of prices received $\bar{Y}_{10}$	$\frac{dY_3}{dY_{10}}$	$\frac{\bar{Y}_{10}}{\bar{Y}_3}$	Elast. e
Table 49, Model 3, Demand, E.N.C.	1244	109.05	4.261	.088	.375
Table 49, Model 3, Demand, W.N.C.(I)	--	--	--	--	--
Table 53, Model 3, Demand, W.N.C.(II)	529.5	109.05	2.014	.206	.418
Table 55, Model 3, Demand, N.C.	2655.8	109.05	8.964	.0411	.368

than the demand elasticities with respect to the farm wage rate. The range is from .071 to .236; this implies that in the short run farmers tend to change more the farm labor input than the farm machinery capital input.

Table 57 contains short run demand elasticities of total farm labor with respect to the index of prices received, estimated at the mean, for three production regions. No elasticity of demand has been estimated for the WNC_I region because the prices received variable did not appear significant in this region. The elasticities denote the responsiveness of the demand for total farm labor to a change in the index of prices received for farm products.

6. Summary and economic implications

The separate analysis of the hired and family farm labor market provided the means of understanding the functioning of the total farm labor market. In all subregions, and in the north central region as a whole, models 2 and 3 provided the basic explanation concerning the total farm labor market. It was expected that the total farm labor market would behave in a way similar to the family labor market. A comparison of these models with the corresponding family farm labor models 6 and 7 of all regions showed that there existed several differences concerning the significance of the coefficients of the prices received and farm machinery variables.

The relative farm wage rate variable appeared to be a better price proxy for the total than the family farm labor. However, it would have been interesting to test another proxy showing the relationship of the farm and the nonfarm income. In all regions the results of model 2 supported the distributed lag hypothesis. It has been argued (2) that the introduction of a lagged endogenous variable would tend to minimize the significance of the coefficients of the rest of the variables in a structural equation, providing the significance was due to a high degree of autocorrelation in each of them. Therefore, the significant coefficients of the rest of the variables in the distributed lag models are of particular importance.

The farm employment and farm machinery data concerning the north central region is obtained by pooling the corresponding data of the three subregions.[1] The inclusion of the ENC region highly affects the statistical results, particularly on the supply side; this can be observed by comparing the model 3 of all regions. Thus the wage rate ratio appears with a negative coefficient which reflects all of the previous results of the ENC region. However, all other coefficients are significant and exhibit the expected sign.

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[1]East north central (ENC), west north central I (WNC_I), and west north central II (WNC_{II}).

The estimated demand and supply elasticities are somewhere between the elasticities of hired and family farm labor; therefore, the short and long run analysis concerning the demand for and supply of hired farm labor, with respect to those variables which cause a shift to the right or to the left, is similar with the analysis of family farm labor. For this reason it will not be repeated. However, the short run impact on farm wages caused by a shift of the demand or the supply curve will be smaller than that on family farm labor because the elasticities are larger.

E. Projections

In this study projections of farm employment levels were made for the three production regions, and for the north central region as a whole, for the years 1975 and 1980. For this purpose the reduced form equation of a simultaneous equation model was used. In each production region, and for each kind of farm labor, one model was chosen. Criteria for the choice were the significance of the structural coefficients which exhibited the signs specified by economic theory, the absence of serial correlation among the residuals, and the high R^2. It was also intended that the model would include the kind of explanatory variables that could be projected with a reasonable degree of accuracy. In our analysis two kinds of models were used according to the above criteria. The first kind included distributed lag models while the second kind did not.

The exogenous variables of the prediction models were the time trend, the value of the stock of farm machinery, and the U.S. unemployment rate. After the data concerning the value of the stock of farm machinery was graphed, it was assumed that this variable was a function of time of the form $y = \alpha T^{\beta}$. The above equation was fitted in a logarithmic form; thus, estimates of α and β were obtained for each particular region and for each kind of farm labor. On the basis of these estimates future levels of the value of the stock of farm machinery were projected for the years 1974 and 1979. There was no attempt to project future levels of the U.S. unemployment rate; however, an upper and a lower limit were set, based on time series data of the past thirty years. Assuming that the unemployment rate would not be more than 6 percent and no less than 3 percent, two projections were made for the years 1975 and 1980 respectively. The projected levels of farm employment that appear in the following tables are the arithmetic average of the two predictions for the same year which were made by using 3 percent and 5 percent unemployment rates in the same prediction equation.

As an example of the procedure that we followed in order to make the projections, we present the following distributed lag model.

Structural equations

Demand: $y_{1t} - b_{12}y_{2t} - \gamma_{11}x_{1t} - \gamma_{12}x_{2t} \qquad - k_1 = 0$

Supply: $y_{1t} - b_{22}y_{2t} \qquad - \gamma_{23}x_{3t} - k_2 = 0$ (4.1)

Reduced form equation

$$\hat{y}_{1t} = \frac{b_{22}\gamma_{11}}{b_{22}-b_{12}} x_{1t} + \frac{b_{22}\gamma_{12}}{b_{22}-b_{12}} x_{2t} - \frac{b_{12}\gamma_{23}}{b_{22}-b_{12}} y_{1_{t-1}} + \frac{b_{22}k_1-b_{12}k_2}{b_{22}-b_{12}} \tag{4.2}$$

where

$$y_{1_{t-1}} = x_{3t} \quad .$$

Equation 4.2 can be written as:

$$y_{1t+1} + \frac{b_{12}\gamma_{23}}{b_{22}-b_{12}} y_{1t} = \frac{b_{22}\gamma_{11}}{b_{22}-b_{12}} x_{1t} + \frac{b_{22}\gamma_{12}}{b_{22}-b_{12}} x_{2t} + \frac{b_{22}k_1-b_{12}k_2}{b_{22}-b_{12}} \quad . \tag{4.3}$$

Equation 4.3 is a first order difference equation of the type

$$y_{t+1} + \alpha y_t = C \quad . \tag{4.4}$$

The general solution of Equation 4.4 is given by the formula (5, pp. 502-514):

$$y_t = (y_o - \frac{C}{1+a})(-a)^t + \frac{C}{1+a} \qquad (a \neq 1) \quad . \tag{4.5}$$

Equation 4.3 can be written as:

$$y_{t+1} + \delta y_t = \alpha_1 x_1 + \alpha_2 x_2 + k \tag{4.6}$$

where

$$\delta = \frac{b_{12}\gamma_{23}}{b_{22}-b_{12}} ,$$

$$\alpha_1 = \frac{b_{22}\gamma_{11}}{b_{22}-b_{12}} ,$$

$$\alpha_2 = \frac{b_{22}\gamma_{12}}{b_{22}-b_{12}} ,$$

$$k = \frac{b_{22}k_1 - b_{12}k_2}{b_{22}-b_{12}} , \quad x_1, \ x_2 \text{ fixed}$$

the general solution of Equation 4.6 is given by the formula:

$$y_t = (y_o - \frac{\alpha_1 x_1 + \alpha_2 x_2 + k}{1+\delta})(-\delta)^t + \frac{a_1 x_1 + \alpha_2 x_2 + k}{1+\delta} \quad . \tag{4.7}$$

In all cases the value of δ was found to be between minus one and zero,

$$-1 < \delta < 0 \quad . \tag{4.8}$$

Table 58 includes the projected levels of the value of the stock of farm machinery for the years 1974 and 1979, and the U.S. rate of unemployment for the same years. Tables 59, 60, and 61 show the prediction equations (which are the reduced form equations) for each kind of farm employment and for each production region, those being derived from the initial structural equations. It is also shown from which model and table each prediction equation was derived. The prediction equations concerning the ENC and NC regions are first order difference equations. The projections concerning the ENC region must be viewed with caution because the greater than one coefficient of the lagged endogenous variable in the initial model implies a negative coefficient of adjustment showing a movement away from equilibrium. For this reason projections of farm employment were made only for the year of 1975. The prediction equations of the WNC_I and WNC_{II} regions include as an exogenous variable the U.S. rate of unemployment which is the only nonagricultural variable in the model influencing the farm labor mobility. Thus the higher unemployment coefficient that appears in the WNC_I region is an indicator of the higher mobility of the farm labor force in this region, in relation to the WNC_{II} region.

Table 62 shows the projected levels of each kind of farm labor and for each production region, based on the prediction equations of Tables 59, 60, and 61.

Table 58. Projected levels of exogenous variables for 1974 and 1979 in the four production regions[a]

Variable	1974	1979
X_6^1	5,090 mil. dol.	5,284 mil. dol.
X_6^2	3,820 mil. dol.	3,990 mil. dol.
X_6^3	3,615 mil. dol.	3,791 mil. dol.
X_6^4	12,430 mil. dol.	12,960 mil. dol.
X_8^a	3%	3%
X_8^b	6%	6%

[a]The value of the stock of farm machinery and the U.S. unemployment rate were lagged one year thus 1974 and 1979 levels of these variables are needed in order to make farm employment projections for 1975 and 1980 respectively.

The value of the time trend for 1975 is 30 and for 1980 it is 35.

Table 59. Prediction equations of hired farm employment (number of workers) in the four production regions for 1975 and 1980

East North Central

From Table 6, model 7:

Prediction equation:

$$y_{t+1} + (-.8435)y_t = (-1.2397)x_{2t} + (.00169)x_{6t}^{1} + 54.76 \tag{4.9}$$

West North Central I

From Table 13, model 8:

Prediction equation:

$$y_t = (-3.558)x_{2t} + (-.01175)x_{6t}^{2} + (3.1008)x_{8t} + 213.209 \tag{4.10}$$

West North Central II

From Table 19, model 8:

Prediction equation:

$$y_t = (-2.3961)x_{2t} + (-.00552)x_{6t}^{3} + (2.532)x_{8t} + 129.0 \tag{4.11}$$

North Central

From Table 24, model 5:

Prediction equation:

$$y_{t+1} + (-.720)y_t = (-3.439)x_{2t} + (.0038)x_{6t}^{4} + 203.4 \tag{4.12}$$

Table 60. Prediction equations of family farm employment (number of workers) in the four production regions

East North Central

From Table 33, model 9:

Prediction equation:

$$y_{t+1} + (-.7196)y_t = (-10.108)x_{2t} + 473.4 \quad (4.13)$$

West North Central I

From Table 35, model 4:

Prediction equation:

$$y_t = (-19.858)x_{2t} + (-.0261)x_{6t}^2 + (8.438)x_{8t} + 1172.8 \quad (4.14)$$

West North Central II

From Table 39, model 4:

Prediction equation:

$$y_t = (-13.117)x_{2t} + (-.0137)x_{6t}^3 + (3.474)x_{8t} + 722.7 \quad (4.15)$$

North Central

From Table 44, model 5:

Prediction equation:

$$y_{t+1} + (-.699)y_t = (-19.483)x_{2t} + (-.0112)x_{6t}^4 + 1126.3 \quad (4.16)$$

Table 61. Prediction equations of total farm employment (number of workers) in the four production regions

East North Central

From Table 48, model 1:

Prediction equation:

$$y_{t+1} + (-.786)y_t = (-9.584)x_{2t} + (-.0051)x_{6t}^{1} + 446.2 \quad (4.17)$$

West North Central I

From Table 51, model 4:

Prediction equation:

$$y_t = (-23.586)x_{2t} + (-.0342)x_{6t}^{2} + (11.569)x_{8t} + 1377.8 \quad (4.18)$$

West North Central II

From Table 53, model 4:

Prediction equation:

$$y_t = (-15.1379)x_{2t} + (-.0205)x_{6t}^{3} + (5.675)x_{8t} + 846.6 \quad (4.19)$$

North Central

From Table 54, model 1:

Prediction equation:

$$y_{t+1} + (-.706)y_t = (-22.631)x_{2t} + (-.0157)x_{6t}^{4} + 1317.8 \quad (4.20)$$

Table 62. Projections of farm employment (number of workers) in the four production regions for 1975 and 1980

Region	Eq. No.	1970 actual	1970 predicted	1975	1980
		Hired Farm Employment			
ENC	4.9	97,000	97,660	45,700	--
WNC_I	4.10	76,000	72,000	54,500	34,500
WNC_{II}	4.11	45,000	44,900	34,135	21,225
NC	4.12	218,000	208,000	135,000	57,000
		Family Farm Employment			
ENC	4.13	670,000	648,000	445,500	--
WNC_I	4.14	502,000	495,000	396,150	291,850
WNC_{II}	4.15	293,000	282,000	216,600	148,600
NC	4.16	1,465,000	1,435,000	1,089,000	629,000
		Total Farm Employment			
ENC	4.17	767,000	745,000	545,200	--
WNC_I	4.18	578,000	566,300	449,850	326,350
WNC_{II}	4.19	338,000	328,000	253,100	173,800
NC	4.20	1,683,000	1,640,000	1,222,000	666,600

F. Comparisons

As indicated in the review of the literature, in some of the studies concerning the farm labor market the distinction between demand and supply variables is not clear, since both categories of variables are used in the specification of the demand function. Therefore, comparisons of the results of this study will be made only with those studies which distinguish clearly between demand and supply variables.

Johnson (14) specified the regional demand for hired farm labor as a distributed lag function of the farm wage rate, the parity ratio, and the time trend; no price or stock value of farm machinery variable was included in the function. Time series data from 1927 to 1957 and from 1940 to 1957 were used for the ENC and WNC regions respectively. The demand for ENC region was found to be a function only of the farm wage rate, and it reacted with a distributed lag type of adjustment. The estimated value of the short run elasticity of demand was .150. In our case, for the same region and aside from the farm wage rate, the time trend and the stock value of farm machinery were found to be significant. The estimated value of the short run elasticity of demand was 1.410. The insignificant parameter estimates of the previous study (14) may be attributed to the incomplete specification of the demand function. The large difference in the estimated elasticities may be attributed to the fact that the two studies cover two different time periods with only 13 overlapping years; in addition, the elasticity of demand for hired farm labor has been increasing over time. This was shown by the same study (14) when different time periods were compared for the whole U.S. For the WNC region the parity ratio was found to be significant, while in our case it exhibited only the expected sign. The estimated elasticity of demand which was .510 can be compared with our estimates which were .874 and 1.375 for the WNC_I and WNC_{II} regions respectively. The regional specification for the demand for family farm labor was similar to the demand for hired farm labor. The stock value of farm machinery was included only in the case of the WNC region. For the ENC region the demand for family farm labor was specified as a distributed lag function of the farm wage rate, the parity ratio, and of the time trend. All coefficients were found significant, but the time trend had a positive, opposite than expected sign. The short run demand elasticity was found to be .210. In our case the demand for family farm labor was found to be significant in all the variables included in Johnson's function in addition to the farm machinery variable. All variables exhibited the signs specified by economic theory. The estimated short run elasticity coefficient was .749. For the WNC region Johnson specified the demand for family farm labor as a function of the farm wage rate, which was insignificant, and of the value of the stock of farm machinery, which was highly significant. There were no variables expressing the parity ratio or the time trend. The insignificant wage rate coefficient and the low coefficient of determination (i.e., $R^2 = .75$) may be attributed to the incomplete specification of the function. No elasticity coefficients were estimated for this region. Johnson did not estimate any regional demand functions for total farm labor or any regional supply equations for the three categories of farm labor. All demand equations were estimated by means of the least squares method.

The only regional analysis of the supply of hired farm labor which came to our attention and can be compared with this study was made by Tyrchniewicz and Schuh (26). The supply was specified to be a distributed lag function of the farm wage rate, the nonfarm income, the civilian labor force, and of the time trend. All parameter estimates, except the farm wage rate in the WNC region, were significant at a 5 percent probability level or better. The coefficient of determination was high and the test concerning serial correlation among the disturbances was inconclusive for the ENC and WNC production regions. In our case the U.S. rate of unemployment was used as a variable expressing nonfarm employment opportunities. The comparison shows that in the case of the ENC region the size of the civilian labor force gives better statistical results than the unemployment rate. However, the explanatory power of the first variable is considered to be rather limited in showing the interrelationship between the farm and the nonfarm labor market.

This comparison (Table 63) shows a similarity between estimated adjustment coefficients and elasticities and the Tyrchniewicz and Schuh estimates. The relatively higher short and long run elasticity estimates of this study can be attributed to the fact that the data which were used cover the period 1965-1970 as well as 1945-1965. The Tyrchniewicz and Schuh elasticities are referring to the single farm wage rate while the elasticities of this study are referring to the relative farm wage rate.

G. Summary and Conclusions

The empirical analysis of the farm labor market of the north central region which has been presented supported the hypothesis that the demand for farm labor is a function of the relative farm wage rate, the value of the stock of farm machinery, and of the index of prices received for farm products. The separate analysis of the hired and family labor market was considered as necessary for a thorough

Table 63. Comparison of the Tyrchniewicz and Schuh (26) coefficients of adjustment and elasticities of farm wage rates with those of this study

Region	Tyrchniewicz and Schuh			This Study		
	Coeff. of adjustment	Short run elasticity	Long run elasticity	Coeff. of adjustment	Short run elasticity	Long run elasticity
East North Central	.33	.316	.958	--	.326	--
West North Central I	--	--	--	.478	.444	.929
West North Central II	--	--	--	.382	.294	.770
West North Central[a]	.34[b]	.207[b]	.609[b]	--	--	--

[a]West north central = west north central I + west north central II.

[b]Computed from coefficients not significant at the 5 percent probability level or better.

examination of the total farm labor market. In the case of the demand for hired farm labor, the prices received variable did not appear significant; while in the case of the demand for family farm labor, the results concerning the time trend were inconclusive.

The results concerning the supply of farm labor supported the hypothesis that it is a function of the relative farm wage rate, the U.S. rate of unemployment, and of the time trend. The distributed lag assumption was also verified. However, it is expected that a more complete model which would include the distributed lag hypothesis and all the supply variables that were found to be significant would further improve the results. The analysis also showed that there is a considerable degree of variation in the results among the three production subregions. Furthermore, the relatively simple model which was employed failed to capture completely the interrelationships of the farm and nonfarm labor market in the more industrialized areas. It is therefore suggested that further research is necessary in order to specify a more suitable supply of hired farm labor.

The Durbin-Watson statistic, which was used as an indicator of autocorrelation, was found either to be high enough to reject the hypothesis of serial correlation in most of the basic explanatory models or that the test was inconclusive.

All equations showed a high coefficient of determination. Although a high R^2 is more or less guaranteed when the lagged endogenous variable is included, all other equations which did not include the distributed lag hypothesis exhibited R^2 of similar magnitude, showing the good fit of all equations tested within the sampling period.

In general, the estimated demand and supply elasticities were found to be higher for the hired than for the family farm labor, while those of the total farm labor were somewhere in between; in particular, the demand for hired labor was found to be elastic in the short run, while the demand for family and total labor was inelastic. The short run elasticities of supply for all categories of farm labor were much lower than the demand elasticities, while the long run supply was found to be elastic. There were also regional variations, with the elasticity being higher in the more industrialized areas. Cross elasticities of demand were also estimated with respect to the index of prices received for farm products and the value of the stock of farm machinery and equipment.

Farm employment projections were also made for the three production regions, and for the NC region as a whole, for the years 1975 and 1980. The reduced form equation of a simultaneous equation model was used for this purpose. Two kinds of models were used for projections. The first was a distributed lag model while the second did not include this hypothesis. The projections concerning the ENC region must be viewed with caution because the estimated coefficient of the lagged endogenous variable was greater than one.

Finally, the two statistical procedures[1] which were employed in the analysis of hired farm labor yielded similar results.

The results of this study have important economic implications for the farm labor market and might be used for certain policy measures which could alleviate the low income problem in the farm sector. Policy measures which are beneficial in the short run might not be satisfactory in the long run. Thus, the various price support programs will increase farm wages in the short run with a relatively minor effect on the employment level; however, since the supply of farm labor is elastic in the long run, the overall effect would be more on farm employment and less on farm wages. Continuous price supports would tend to keep farm labor in the agricultural sector, thus having a negative effect in increasing farm wages and incomes. On the other hand, programs which would improve the information and the skills of the farm labor force for nonfarm employment would

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[1]Least squares and simultaneous equation estimation methods.

have a beneficial effect in both the short and the long run. In the short run the overall effect would be more in raising farm wages than in reducing total employment, while in the long run the impact would be more in farm employment. A smaller farm labor force, with the total value of farm output unchanged, would imply a higher per capita farm income. Favorable economic conditions in the whole economy would facilitate the implementation of such policy measures. Finally, a fixed minimum farm wage rate above its equilibrium level would increase the quantity of farm labor supplied and decrease the quantity demanded, thus leaving a portion of the farm labor force unemployed. However, a situation similar to this would be considered only as a short run phenomenon if it is viewed in combination with the various educational programs which tend to shift the supply curve of farm labor to the left, thus reducing the equilibrium employment level.

V. EMPIRICAL ESTIMATES OF THE DEMAND FOR FARM LABOR IN THE UNITED STATES

As stated in the introduction, the focus of this study has been primarily on the north central region and on the demand for farm labor in general, because the factors that influence the demand can be identified and quantified more accurately than those that influence the supply. Thus having tested the original hypothesis concerning the regional labor market, one can proceed to the empirical analysis of the aggregate U.S. farm labor market. However, a full scale analysis of this sort would be beyond the scope of this study. For this reason only an empirical analysis of the demand for farm labor has been made.

In general, the hypothesis which will be tested is similar with the hypothesis concerning the north central region. In particular, the demand for farm labor is assumed to be a function of its price, the index of the price of farm output, the value of the stock of farm machinery, and of the time trend which is used as an indicator of technological change. Again, the hired and family farm labor are analyzed separately for the purpose of understanding the functioning of the demand for total farm labor. Since the procedure and rationale of including or excluding one variable from the demand function are similar with those of the regional empirical analysis, they will not be repeated.

The statistical methods which were employed in the empirical analysis of the aggregate demand functions were those of the ordinary and generalized least squares. The quantity of farm labor was considered to be endogenous, while the farm wage rate lagged one year and the rest of the explanatory variables were treated as exogenous. The value of the stock of farm machinery and the prices received for farm products variables have also been lagged one year, which implies that farm operators base their current decisions concerning farm labor inputs on last year's values and prices.

At the outset of the analysis a large number of equations and variables were tested by means of ordinary least squares. Finally, the equations which included the most meaningful explanatory variables, as far as the original hypothesis is concerned, were chosen; other criteria were the absence of serial correlation among the residuals and the high coefficient of determination used as indicator of a good fit. Those equations which included variables with significant coefficients but exhibited autocorrelated errors were tested again, after all variables were transformed, by means of generalized least squares. In order to transform the variables in each equation, it was hypothesized that the residuals follow a first order autoregressive scheme (i.e., $u_t = \hat{\rho}u_{t-1} + e_t$); then the estimated value of ρ was used for the transformation.

Two proxies were used as the price of farm labor;[1] the annual farm wage rate was used as the price of hired labor, and the operator's realized income as the price of family labor. The same proxy was also used in the case of total farm labor. Short run price and income elasticities of demand have been estimated for all three categories of farm labor, and comparisons have been made with the regional estimates. Time series data were used in the analysis covering the period 1941-1969. The following list indicates all the variables that were used in the empirical analysis of the aggregate demand for farm labor in the U.S.

A. List of Variables

Endogenous:

y_1 = quantity of hired farm labor in 1,000 persons.

y_2 = quantity of family farm labor in 1,000 persons.

y_3 = quantity of total farm labor in 1,000 persons.

Exogenous:

x_1 = time trend (i.e., $t_{1941} = 1$, $t_{1942} = 2$, ..., $t_{1969} = 29$).

x_2 = annual wage rate per hired farm worker in constant 1957-59 dollars (deflator: prices paid for living

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[1]For a detailed discussion on the data construction and development see the Appendix.

expenses 1957-59 = 100).

x_3 = variable x_2 lagged one year.

x_4 = operator's realized income (per farm) in constant 1957-59 dollars (deflator: prices paid for living expenses 1957-59 = 100) lagged one year.

x_5 = value of the stock of farm machinery in constant 1957-59 billion dollars (deflator: price index of farm machinery 1957-59 = 100) lagged one year.

x_6 = price index of farm machinery 1957-59 = 100.

x_7 = index of prices received (1957-59 = 100) deflated by the index of prices paid for production expenses (1957-59 = 100).

x_8 = quantity of hired farm labor in 1,000 persons lagged one year (i.e., $x_8 = y_{1_{t-1}}$).

B. Hired Farm Labor

1. Equations 1, 2, 3, and 4

In equation 1 the demand for hired farm labor is specified as a function of the annual farm wage rate lagged one year, the value of the stock of farm machinery, and of the time trend. The index of prices received for farm products was not included in the demand function because of the insignificant coefficient in the regional analysis. All variables of equation 1 exhibit the expected signs and are statistically significant except for the farm machinery. The specification of the demand for hired labor appears to be better in equation 2 when the current farm wage rate is treated as an exogenous variable. All coefficients are significant and have a smaller standard error. The better results of equation 2 can be explained partially by equation 4 when the distributed lag assumption has been made. The high value of the adjustment coefficient[1] implies that most of the change in the quantity demanded attributed to a change in the price of farm labor will occur in less than a year. Therefore, the current farm wage rate appears to be a better proxy as the price of hired farm labor than its lagged value; however, it is recognized that in this case the simultaneous equation estimation is more appropriate, since the current farm wage rate cannot be treated as a truly exogenous variable.

The parameter estimates of equations 1, 2, and 3 were obtained by means of generalized least squares. The relatively high value of the Durbin-Watson statistic indicated an absence of autocorrelation among the residuals after the variables were transformed, and corroborated the hypothesis that the residuals of the original equation followed a first order autoregressive scheme. The distributed lag equation 4

[1] $\gamma = .687$.

was estimated by means of ordinary least squares. The low value of the Durbin-Watson statistic can be attributed to the autocorrelated residuals and partially to the incomplete specification of the demand function, since the stock value of farm machinery was not included.

The estimated short run elasticities, which are presented in Table 67, indicate that the aggregate demand for hired farm labor is inelastic with elasticity coefficients ranging from .419 to .562. These values can be compared with the elasticity coefficients of the north central region where the demand for hired farm labor was found to be elastic. The difference in the elasticities can be explained by the fact that the results concerning the aggregate demand for hired farm labor are influenced by other regions with much lower elasticities of demand. The low value of the cross elasticity coefficient in respect to the stock of farm machinery indicates that, in the short run, the change of the quantity of hired labor demanded due to a change in the value of farm machinery is minimum.

Finally, the results of the empirical analysis corroborated the hypothesis that the demand for hired farm labor is a function of the annual farm wage rate, the value of the stock of farm machinery, and of the time trend. All parameter estimates of the demand equations 1, 2, 3, and 4 are presented in Table 64.

C. Family Farm Labor

1. Equations 1, 2, and 3

The demand for family farm labor is specified as a function of the operator's realized income, the index of prices received for farm products, the value of the stock of farm machinery, and of the time trend. This specification is shown in equation 2. All variables of equation 2 exhibit significant coefficients with the expected sign except the value of the stock of farm machinery which has a negative though insignificant coefficient; however, its standard error is smaller than the parameter estimate. The elimination of this variable from the demand function did not improve the statistical results, which implies that the specification is more correct when the farm machinery variable is included. This is shown in equation 1, in which almost all estimated parameters have a smaller value than those of equation 2. The highly significant coefficient of the operator's realized income indicates that this variable is a good proxy as the price of family farm labor. Likewise, the significant coefficient of the index of prices received for farm products indicates that the demand for family farm labor is responsive to changes in this variable.

Equations 1 and 2 were estimated by means of ordinary least squares, but no conclusions concerning the degree of autocorrelation among the residuals can be drawn since the Durbin-Watson test is inconclusive. Equation 3 includes the same variables as equation 1 with the hypothesis that the disturbances follow a first order autoregressive scheme. All regression coefficients were estimated by means of generalized least squares. The results, however, were less satisfactory than those of equation 1. All parameter estimates, with the exception of the time trend, exhibited smaller values and larger standard errors, the fit was less satisfactory than before, and the Durbin-Watson test was still inconclusive. Therefore, the hypothesis that the residuals follow a first order autoregressive scheme was rejected suggesting that further analysis on the distribution of the errors is required.

The estimated short run elasticities indicate that the demand for family farm labor is inelastic with elasticity coefficients (see Table 67) lower than those of hired farm labor. Thus a ten percent decrease in the price of family farm labor will increase its demand by less than three percent. The cross elasticity of demand with respect to prices received, although less than one, is much larger than the previous one. This can be explained by the fact that the family wage rate or any other proxy of it, although difficult to estimate, is not an out of pocket cost as it is in the case of hired farm labor. Thus, the

Table 64. Demand equations[a] for hired farm labor in the United States

Eq. No.	Constant term	d[b]	R^2	$\hat{\rho}$[c]	γ[d]
1	$y_1 = 1297.2^{**} - .557^{**}X_2 - 30.38^{**}X_1 - 7.696\ X_5$	1.80	.819	.702**	
	$(74.8)\quad(.130)\quad(6.78)\quad(8.98)$			(.130)	
2	$y_1 = 2303.8^{**} - .735^{**}X_3 - 21.12^{**}X_1 - 13.650^{**}X_5$	1.90	.968	.467**	
	$(50.6)\quad(.070)\quad(3.86)\quad(5.36)$			(.154)	
3	$y_1 = 1261.6^{**} - .548^{**}X_2 - 34.094^{**}X_1$	1.65	.805	.713**	
	$(73.8)\quad(.130)\quad(5.482)$			(.131)	
4	$y_1 = 2973^{**} - .469^{**}X_3 - 19.65^{**}X_1 + .313^{**}X_8$	.935[C]	.983	--	.687
	$(617)\quad(.981)\quad(4.579)$				

[a]Equations 1, 2, and 3 were estimated by generalized least squares, equation 4 by ordinary least squares.

[b]C = autocorrelated errors; I = inconclusive.

[c]$\hat{\rho}$ = estimated coefficient of the autocorrelated errors (i.e., $u_t = \rho u_{t-1} + e_t$).

[d]γ = adjustment coefficient.

demand for family farm labor appears more responsive to a change in the prices received for farm products variable. Finally, the cross elasticity of demand with respect to the stock value of farm machinery is very low and smaller than that of hired labor's, indicating that capital substitutes firstly for hired and secondly for family farm labor.

The results of the empirical analysis corroborated the hypothesis that the demand for family farm labor is a function of the operator's realized income used as a proxy of its price, the index of prices received for farm products, and of the time trend as an indicator of technological change. It might be argued that farm operators will demand more family labor when its return increases, the result being an upward sloping demand curve. However, it is difficult to hypothesize which is the actual price of family farm labor since the latter is composed of family members' and operator's labor. Therefore, the role of the operator must be viewed as the one in which he tries to minimize his cost by decreasing the quantity demanded of farm inputs when their price is increasing (a demand phenomenon), and as resource owner by trying to increase his factor returns (a supply phenomenon).

Table 65. Demand equations[a] for family farm labor in the United States

Eq No.	Constant term					d[b]	R^2	$\hat{\rho}$[c]
1	$Y_2 = 9748^{**}$	$-\,.517^{**}X_4$	$+\,43.687^{**}X_7$		$-\,123.66^{**}X_1$	1.01^{I}	.992	--
	(655)	(.093)	(4.690)		(8.75)			
2	$Y_2 = 8357^{**}$	$-\,.589^{**}X_4$	$+\,45.744^{**}X_7$	$-\,17.847X_5$	$-\,109.138^{**}X_1$	1.18^{I}	.993	--
	(724)	(.111)	(4.976)	(15.249)	(15.149)			
3	$Y_2 = 5398^{**}$	$-\,.401^{**}X_4$	$+\,34.27^{**}X_7$		$-\,138.28^{**}X_1$	1.10^{I}	.980	.464**
	(817)	(.132)	(9.480)		(18.18)			(.166)

[a] Equations 1 and 2 were estimated by ordinary least squares, equation 3 was estimated by generalized least squares.

[b] C = autocorrelated errors; I = inconclusive.

[c] $\hat{\rho}$ = estimated coefficient of the autocorrelated errors (i.e., $u_t = \rho u_{t-1} + e_t$).

D. Total Farm Labor

1. Equations 1, 2, and 3

The specification of the total farm labor is similar with that of family farm labor. That is, the demand for total labor is a function of the operator's realized income, the index of prices received for farm products, the value of the stock of farm machinery, and of the time trend. This is shown in equation 1, whose all parameter estimates are significant at a 5 percent probability level or better and exhibit the expected signs. The significance of the machinery coefficient is of particular importance since in the demand for family farm labor it is not significant at all, and in the case of hired farm labor it is significant only when the current farm wage rate is used as its price. In respect to the other variables the demand for total farm labor behaves as that of hired labor. The highly significant coefficients of the operator's realized income and the prices received variable show that the demand is responsive to changes in these variables. Equations 2 and 3 were included for the purpose of making comparisons between ordinary and generalized least squares statistical estimation. Both include the same variables; however, there was no improvement in the results when the first order autoregressive scheme was hypothesized for the residuals. The

Durbin-Watson test concerning the degree of autocorrelation was inconclusive in all three equations.

The estimated elasticities in respect to the operator's realized income were as expected, that is, lower than those of hired labor and higher than those of family labor; while the cross elasticity of total labor demanded in respect to the prices received variable was somewhat lower. The cross elasticity in respect to the value of the stock of farm machinery is very low and between the demand elasticities of hired and family farm labor

E. Comparisons

Johnson (14) found the aggregate demand for hired farm labor in the U.S. to be a function of the farm wage rate, the index of prices received for farm products, and of the value of farm machinery. However, the sign of the farm machinery variable was positive which implies complementarity rather than substitutability between machinery capital and labor. This interpretation cannot be considered realistic, since a complementary relationship between labor and total capital stock of farm machinery and equipment must be viewed as a very short run phenomenon. The time trend which was included in the specification of the demand function was found to be insignificant. In our case both variables (i.e., farm machinery and time trend) were found to be significant exhibiting the expected signs. However, the prices received variable was not included in the demand function for hired farm labor since in the regional analysis it did not appear to be significant. Johnson specified the demand for family labor to be a function of the farm wage rate, the time trend, and of the prices received. All regression coefficients were significant and exhibited the expected signs, but this specification is evidently incomplete since there is no variable in the function to take into account the relationships of family labor with the other farm inputs. This is supported by the significant and negative farm machinery coefficient of our analysis. Finally, he found the demand for both hired and family farm labor to be inelastic in the short run with elasticity coefficients somewhat smaller (14, pp. 58, 92-94) than those of this study. This can be explained by the fact that the two studies cover different time periods with only thirteen years overlapping.

Heady and Tweeten (11, pp. 219-222) tested a number of demand equations for hired farm labor (using data from 1926 to 1959 but not 1942 to 1945) which included wage-price ratios in both current and lagged form in order to examine to what extent the demand for hired farm labor is affected by changes in the price of operating inputs and of farm machinery. The stock value of productive farm assets and

Table 66. Demand equations for total farm labor in the United States

Eq. No.		Constant term					d	R^2	$\hat{\rho}$
1	$y_3 =$	11015**	$-\ .997^{**}X_4$	$+\ 56.321^{**}X_7$	$-\ 39.362^{**}X_5$	$-\ 113.21^{**}X_1$	1.42^{I}	.992	
		(905)	(.139)	(6.222)	(19.068)	(18.94)			
2	$y_3 =$	11836**	$-\ .837^{**}X_4$	$+\ 51.785^{**}X_7$		$-\ 145.25^{**}X_1$	1.04^{I}	.991	
		(865)	(.123)	(6.189)		(11.54)			
3	$y_3 =$	7013**	$-\ .686^{**}X_4$	$+\ 43.866^{**}X_7$		$-\ 158.74^{**}X_1$	1.37^{I}	.988	.453
		(1109)	(.177)	(12.64)		(24.12)			(.170)

Table 67. Demand elasticities of farm labor in the United States (estimated at the mean)

Eq. No.	Table No.	Price[a] elasticity				Cross elasticity with respect to prices received			Cross elasticity with respect to the stock value of farm machinery		
		$\bar{Y}$	$\bar{X}$	$\frac{dY}{dX}$	e	$\bar{X}$	$\frac{dY}{dX}$	e	$\bar{X}$	$\frac{dY}{dX}$	e
					Hired Farm Labor						
1	1	1974	1511	.557	.426			--	16.4	7.696	.064[b]
2	1	1974	1557	.735	.562			--	16.4	13.650	.113
3	1	1974	1557	.548	.419			--	--	--	--
					Family Farm Labor						
1	2	6164	3102	.517	.260	107.79	43.687	.760	--	--	--
2	2	6164	3102	.589	.296	107.79	45.744	.796	16.4	17.847	.046
3	2	6164	3102	.401	.201	107.79	34.27	.596	--	--	--
					Total Farm Labor						
1	3	8139	3102	.997	.380	107.79	56.321	.743	6.4	39.362	.079
2	3	8139	3102	.837	.319	107.79	51.785	.684	--	--	--
3	3	8139	3102	.686	.261	107.79	43.866	.579	--	--	--

[a]Annual farm wage rate or operator's realized income.

[b]Estimated from an insignificant coefficient.

the time trend were also included in the function. The results of the analysis supported the hypothesis that the demand for hired labor is a function of the ratio of the farm wage rate to prices received lagged one year, of the time trend, and of the stock of productive farm assets. However, the last variable appeared with a positive coefficient which gives only a short run explanation. Equations with the distributed lag assumption were also tested; but when farm assets variable was present, the coefficient of the lagged endogenous variable was insignificant. In our case the value of the stock of farm machinery appeared always with a negative sign and was significant when the current farm wage rate was present. The adjustment coefficient of the distributed lag equation was also higher (i.e., .7 versus .5). This difference in the results between the two studies might be explained by the somewhat different specification of the demand function and by the fact that they covered different time periods. No further comparisons will be made with the rest of the studies mentioned in the review of literature because of the quite different specification of the demand function for farm labor which often includes supply variables as well.

F. Summary and Conclusions

In this chapter an empirical analysis of the aggregate demand for farm labor in the U.S. was conducted. The preceding regional analysis of the farm labor market of the north central region is an important step toward a full scale analysis of the U.S. farm labor market. Also the separate analysis of the demand for hired and family farm labor has been crucial in determining the factors that influence the demand for total farm labor.

The results supported the hypothesis that the aggregate demand for total farm labor is a function of the operator's realized farm income, the index of prices received for farm products, the stock value of farm machinery, and of the time trend reflecting the changes in technology. The coefficient of determination in all equations was high enough to guarantee a good fit within the sampling period. The Durbin-Watson test concerning the degree of autocorrelation among the residuals was in most cases inconclusive; however, the hypothesis that the residuals follow a first order autoregressive scheme did not improve the results in all cases.

The elasticity of demand of all categories of farm labor, which was found to be very low in the short run, is related to the structural rigidities that exist in the farm sector. The assumption that the demand for farm labor is better related to the stocks of such productive farm assets as the farm machinery rather than to the price of operating inputs was also supported by the results. The low demand elasticities imply that farm operators do not change their capital stock significantly in the short run if a change occurs in the farm wage rate or in the prices received for farm products. This happens because the substitution of capital for labor in agriculture requires time. The organization of the farm structure is closely related to the substitutability of capital for labor; thus farm operators might postpone purchases of new machinery and equipment until they increase the farm size by purchasing or renting more land.

The significance of the time trend with a negative coefficient as a variable in the demand function for farm labor implies that the demand curve will shift to the left over time due to the technological innovations and the improved quality of farm equipment. The adaptation of the farm sector to new systems requires new organization of the farms which will probably take a considerable amount of time. The comparison of our analysis with other studies and some of the previous studies themselves (11, 14) have shown that the demand elasticity has been increasing over time. This can be attributed to the improved level of education and communication of the farm labor force. However, the low farm incomes and wages which are still prevailing in the farm sector, in relation to the nonfarm incomes and wages, show that the public and private investment in factors affecting the mobility of the farm labor force has not been adequate.

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VIII. APPENDIX

The Data

The nature and the sources of all the necessary data which was used for the development of all regional and national variables of the empirical analysis are discussed below.

There are two methods by which the data concerning the quantity of hired, family and total farm labor is developed. The first method measures the number of persons and the number of hours they worked each year. Then on the basis of this information an estimate of "man-hours" worked is derived. The second method sets a minimum level of farm work throughout the year and counts the number of persons who were on the farms during that period. Annual estimates of farm labor by both methods are made by the United States Department of Agriculture.[1] In this study estimates of farm labor made by the second method were used, because the focus of the analysis and the resulting policy implications was on the number of people involved in the prediction process rather than on the amount of man-hours worked during the year.

Regional variables: State data concerning estimates of

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[1]For more details concerning these estimates see reference 31, pp. 2-3 and reference 34, pp. 3-4.

the quantity of hired, family and total farm labor were obtained from United States Department of Agriculture reports (28, 34), then farm labor estimates for each subregion were obtained from summing the state data. Since no state data are reported for the 1939-1949 period, the quantity of farm labor in the subregions WNC_I and WNC_{II} was assumed to be a linear function of the quantity of farm labor in the west north central region of the form $Y = a + bX$. The parameters a and b were estimated by using data from 1950 to 1970; then farm labor estimates for the two subregions were predicted for the 1939-1949 period. All regional data concerning hired, family and total farm labor are presented in Tables A1, A2, and A3. Data concerning the rest of the regional variables are summarized in Tables A4 through A11.

State data concerning the index of the composite farm wage rate were taken from United States of Agriculture reports (35). The farm wage rate for each region was obtained by using as weights the number of hired farm workers in each state. Since no state estimates are reported earlier than 1948, the regional farm wage rate was assumed to be linearly related with the U.S. farm wage rate. As in the case of farm labor, the regression coefficients a and b were estimated and values of the regional farm wage rate were predicted for 1939-1947.

State data concerning the hourly wage rate in manufacture were taken from United States of Commerce reports (39). The wage rate in manufacture for each region was obtained by using as weights the number of employees on payrolls of manufacturing establishments in each state which were taken from report (41). Since no state estimates of the wage rate in manufacture are reported earlier than 1950, the regional wage rate was assumed to be a linear function of the U.S. wage rate in manufacture and regional estimates for the period 1939-1949 were obtained as in the case of the farm wage rate.

The gross farm income was defined as the sum of: receipts from farm marketings plus the value of home consumption plus government payments. State data concerning the farm income components were taken from reports (37). Regional estimates of gross farm income were derived by summing the state data. State data concerning the farm population were taken from U.S. Department of Agriculture reports (29, 30, 31). For the years 1939 to 1960 regional totals of farm population were obtained from summing state data. For the years 1961 to 1970 when no state data were reported the farm population of each region was assumed to be a linear function of the total U.S. farm population. Then for each region farm population estimates were predicted for 1961-1970. The gross farm income per capita for each region was computed by dividing the total gross farm income by the corresponding farm population.

State data concerning the value of the stock of farm machinery and equipment for the period 1945-1965 were taken from source (32). Since no state data of farm machinery are reported after 1965, estimates of the stock values for the years 1966, 1967, 1968, and 1969 were derived based on information concerning the machinery expenditures by state, the total U.S. machinery expenditures and the total U.S. machinery depreciation. In particular, the depreciation of farm machinery and equipment for each state was derived by multiplying the ratio of machinery expenditures by state to the total U.S. machinery expenditure times the total U.S. machinery depreciation. Then the depreciation for each state was computed for the years 1950 to 1969. All data concerning farm machinery expenditures and depreciation were taken from reports (43, 44, 45). The next step was to estimate depreciation rates in each state by dividing the value of state depreciation by the corresponding stock value, for the period 1950-1965; then the average depreciation rate for each state was computed. The stock values of farm machinery for each state for the years 1966, 1967, 1968, and 1969 were computed by multiplying the average depreciation rate by the state depreciation. Estimates of the stock values of farm machinery for the ENC, WNC_I, WNC_{II} and NC regions were obtained from summing the state estimates.

The U.S. rate of unemployment was taken from report (40), while the index of prices received by farmers for farm products was taken from report (36).

Variables used in the demand analysis of the United States: Estimates of the quantity of hired, family, and total farm labor in the U.S. were taken from reports (28). The annual wage rate per hired farm worker was computed by dividing the total farm wages (32), by the total number of hired farm workers. The operator's realized net income per farm was taken from report (37), and the value of the stock of farm machinery and equipment from (33). The price index of farm machinery, the index of prices received for farm products and the index of prices paid for production expenses were taken from reports (36). The consumer price index was taken from report (8).

Tables

Table A1. Regional hired farm labor in 1,000 workers

Year	ENC	WNC_I	WNC_{II}	NC
1939	328.0	187.7	119.3	635.0
1940	319.0	192.6	122.4	634.0
1941	300.0	196.3	124.7	621.0
1942	278.0	189.6	120.4	588.0
1943	261.0	177.3	112.7	551.0
1944	228.0	161.3	102.7	492.0
1945	214.0	147.3	93.8	455.0
1946	222.0	162.0	103.0	487.0
1947	220.0	177.3	112.7	510.0
1948	229.0	181.0	115.0	525.0
1949	231.0	167.5	106.5	505.0
1950	237.0	170.0	105.0	512.0
1951	236.0	160.0	97.0	493.0
1952	226.0	147.0	92.0	465.0
1953	213.0	142.0	90.0	445.0
1954	215.0	140.0	88.0	443.0
1955	206.0	134.0	82.0	422.0
1956	196.0	124.0	77.0	397.0
1957	192.0	123.0	81.0	396.0
1958	195.0	126.0	86.0	407.0
1959	187.0	121.0	82.0	390.0
1960	182.0	114.0	82.0	378.0
1961	182.0	111.0	77.0	370.0
1962	177.0	121.0	77.0	375.0
1963	177.0	114.0	70.0	361.0
1964	152.0	100.0	64.0	316.0
1965	133.0	95.0	60.0	288.0
1966	117.0	86.0	60.0	263.0
1967	108.0	85.0	54.0	247.0
1968	102.0	80.0	47.0	229.0
1969	94.0	75.0	46.0	215.0
1970	97.0	76.0	45.0	218.0

Table A2. Regional family farm labor in 1,000 workers

Year	ENC	WNC_I	WNC_{II}	NC
1939	1321.0	944.9	573.3	2836.0
1940	1285.0	929.1	563.1	2774.0
1941	1258.0	916.3	554.8	2726.0
1942	1260.0	908.4	549.6	2715.0
1943	1258.0	929.7	563.5	2748.0
1944	1257.0	937.0	568.2	2759.0
1945	1257.0	937.6	568.6	2760.0
1946	1295.0	975.4	593.1	2860.0
1947	1303.0	1002.8	610.9	2913.0
1948	1335.0	1013.2	617.6	2962.0
1949	1282.0	967.5	588.0	2834.0
1950	1331.0	937.0	569.0	2835.0
1951	1306.0	898.0	550.0	2754.0
1952	1295.0	873.0	534.0	2702.0
1953	1274.0	864.0	520.0	2658.0
1954	1250.0	844.0	506.0	2600.0
1955	1218.0	831.0	501.0	2539.0
1956	1163.0	771.0	468.0	2394.0
1957	1115.0	751.0	451.0	2310.0
1958	1093.0	748.0	451.0	2282.0
1959	1066.0	733.0	444.0	2236.0
1960	1038.0	717.0	421.0	2176.0
1961	1099.0	709.0	410.0	2218.0
1962	968.0	694.0	404.0	2066.0
1963	937.0	683.0	390.0	2010.0
1964	892.0	662.0	376.0	1930.0
1965	819.0	609.0	351.0	1779.0
1966	769.0	571.0	333.0	1673.0
1967	715.0	542.0	318.0	1575.0
1968	696.0	526.0	311.0	1533.0
1969	677.0	516.0	300.0	1493.0
1970	670.0	502.0	293.0	1465.0

Table A3. Regional total farm labor in 1,000 workers

Year	ENC	WNC_I	WNC_{II}	NC
1939	1649.0	1132.7	688.8	3471.0
1940	1604.0	1121.7	681.8	3408.0
1941	1558.0	1112.5	676.0	3347.0
1942	1538.0	1097.9	666.6	3303.0
1943	1519.0	1107.0	672.5	3299.0
1944	1485.0	1098.5	667.0	3251.0
1945	1471.0	1085.0	658.4	3215.0
1946	1517.0	1137.5	691.9	3347.0
1947	1523.0	1180.3	719.1	3423.0
1948	1593.0	1184.6	721.9	3500.0
1949	1542.0	1129.0	686.5	3358.0
1950	1568.0	1107.0	672.0	3347.0
1951	1542.0	1058.0	647.0	3247.0
1952	1521.0	1020.0	626.0	3167.0
1953	1487.0	1006.0	610.0	3103.0
1954	1465.0	984.0	594.0	3043.0
1955	1424.0	965.0	572.0	2961.0
1956	1359.0	895.0	537.0	2791.0
1957	1307.0	874.0	525.0	2706.0
1958	1288.0	874.0	527.0	2689.0
1959	1253.0	854.0	519.0	2626.0
1960	1220.0	831.0	503.0	2554.0
1961	1191.0	820.0	487.0	2498.0
1962	1145.0	815.0	481.0	2441.0
1963	1114.0	796.0	461.0	2371.0
1964	1044.0	762.0	440.0	2246.0
1965	952.0	704.0	411.0	2067.0
1966	886.0	657.0	393.0	1936.0
1967	823.0	627.0	372.0	1822.0
1968	798.0	606.0	358.0	1762.0
1969	771.0	591.0	346.0	1708.0
1970	767.0	578.0	338.0	1683.0

Table A4. Index of the composite farm wage per hour (1957-59 = 100) deflated by the index of prices paid for living expenses

Year	ENC	WNC_{I}	WNC_{II}	NC
1939	50.88	79.03	79.66	72.55
1940	51.17	79.23	79.85	72.74
1941	54.60	81.51	82.06	74.89
1942	60.34	85.32	85.77	78.50
1943	69.50	91.40	91.68	84.26
1944	78.04	97.06	97.18	89.63
1945	83.59	100.75	100.77	93.12
1946	81.56	99.40	99.46	91.85
1947	76.28	95.90	96.05	88.52
1948	76.03	95.73	95.89	88.37
1949	76.34	95.93	96.09	88.56
1950	74.84	94.94	95.12	89.16
1951	75.77	95.56	95.72	87.01
1952	79.43	97.99	98.08	90.81
1953	81.25	99.20	99.26	93.43
1954	80.60	98.77	98.84	91.95
1955	81.40	99.29	99.35	92.58
1956	83.01	100.37	100.39	92.87
1957	83.82	100.90	100.91	92.10
1958	84.57	101.40	101.40	91.86
1959	89.04	104.37	104.28	95.45
1960	90.86	105.58	105.46	96.54
1961	91.82	106.21	106.08	97.42
1962	93.06	107.03	106.87	98.89
1963	94.29	107.86	107.67	99.75
1964	95.66	108.76	108.55	100.94
1965	98.12	110.40	110.14	102.71
1966	102.17	113.08	112.75	105.94
1967	107.11	116.36	115.94	108.70
1968	110.93	118.90	118.41	110.25
1969	115.94	122.23	121.64	113.22
1970	118.86	124.16	123.51	115.30

Table A5. Ratio[a] of the index of the deflated composite farm wage rate per hour (1957-59 = 100) to the index of the deflated hourly wage rate in manufacture (1957-59 = 100)

Year	ENC	WNC_I	WNC_{II}	NC
1939	87.21	147.74	131.61	124.51
1940	84.46	141.45	127.58	120.19
1941	84.71	135.08	124.03	116.33
1942	87.85	131.10	122.50	114.42
1943	94.92	130.28	123.60	115.20
1944	102.15	131.69	126.07	117.44
1945	111.58	139.83	133.06	124.43
1946	111.87	142.41	134.61	126.11
1947	105.86	139.23	131.38	122.99
1948	104.01	136.72	129.46	121.01
1949	99.19	129.06	123.82	115.20
1950	93.04	119.80	122.69	110.88
1951	94.63	124.91	122.53	109.22
1952	95.83	119.53	118.70	109.33
1953	92.65	114.78	113.91	106.78
1954	90.44	111.53	108.81	103.36
1955	86.67	107.48	106.03	98.66
1956	85.60	104.56	103.11	95.75
1957	85.51	103.42	101.98	93.83
1958	95.65	101.78	102.27	93.91
1959	86.50	101.78	102.58	92.89
1960	86.86	100.48	102.07	92.33
1961	96.68	98.73	100.60	92.03
1962	85.91	97.77	99.08	91.30
1963	85.60	96.96	98.56	90.50
1964	85.23	96.01	97.48	90.14
1965	86.19	95.75	98.93	90.37
1966	89.05	97.32	100.36	92.43
1967	92.69	98.06	102.64	94.11
1968	93.32	98.38	103.95	92.94
1969	97.08	100.42	108.03	94.69
1970	100.18	101.61	107.64	97.18

[a]The ratio has been multiplied by 100.

Table A6. Gross farm income per capita in constant (1957-59 dollars) deflated by prices paid for living expenses

Year	ENC	WNC_I	WNC_{II}	NC
1940	1001.94	1241.44	1237.63	1121.91
1941	1209.74	1475.62	1542.52	1356.09
1942	1477.78	1842.89	2084.69	1707.00
1943	1716.14	2236.66	2649.42	2054.77
1944	1772.59	2144.95	2599.12	2044.29
1945	1760.30	2175.37	2760.78	2077.78
1946	1893.56	2255.65	2799.44	2176.35
1947	1835.80	2386.04	3096.99	2243.20
1948	1870.34	2250.47	2964.10	2191.35
1949	1484.38	2106.57	2667.38	1997.46
1950	1713.43	2227.67	2768.26	2068.85
1951	1897.94	2301.94	2915.64	2214.18
1952	1897.47	2190.24	2876.43	2170.85
1953	1944.66	2317.83	2692.52	2204.39
1954	1910.80	2306.85	2712.28	2189.04
1955	1813.93	2170.79	2568.06	2070.65
1956	1941.15	2195.01	2560.69	2139.20
1957	2006.43	2291.46	2610.58	2194.51
1958	2092.78	2588.92	3303.21	2483.88
1959	1997.37	2472.00	3276.80	2394.92
1960	2177.47	2698.33	3381.48	2574.51
1961	2364.07	2816.23	3789.63	2777.82
1962	2470.33	2951.00	4026.01	2917.95
1963	2574.64	3047.07	4269.75	3045.91
1964	2644.22	3168.20	4152.77	3098.89
1965	2786.47	3485.24	4562.17	3350.19
1966	3186.62	3820.25	5419.30	3813.23
1967	3046.11	3754.12	5410.75	3723.43
1968	3118.69	3822.31	5406.81	3781.07
1969	3178.59	4045.97	5802.73	3959.40
1970	3162.59	4015.82	5787.32	3939.82

Table A7. Value of the stock of farm machinery in constant (1957-59) millon dollars, deflated by the index of prices paid for production expenses

Year	ENC	WNC_I	WNC_{II}	NC
1939	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0
1945	2235.20	1518.80	1238.30	4992.30
1946	1683.80	1148.20	974.60	3806.60
1947	1385.10	947.50	836.90	3169.50
1948	1700.10	1168.50	1073.90	3942.50
1949	2393.10	1645.20	1575.10	5613.40
1950	2792.00	1934.40	1846.20	6572.60
1951	2907.20	2039.10	1916.20	6862.50
1952	3426.00	2406.00	2259.40	8091.30
1953	3847.20	2715.60	2557.00	9119.80
1954	4096.10	2900.50	2711.60	9708.20
1955	4200.40	2998.30	2789.30	9988.60
1956	4387.20	3143.00	2916.60	10446.90
1957	4454.90	3207.20	2949.90	10612.00
1958	4310.90	3130.10	2876.00	10316.90
1959	4642.00	3385.80	3072.50	11100.30
1960	4739.30	3481.20	3182.70	11403.10
1961	4657.20	3436.90	3147.80	11241.90
1962	4680.70	3469.30	3153.90	11303.90
1963	4705.80	3494.10	3171.30	11372.10
1964	5032.40	3740.60	3363.10	12136.10
1965	5236.50	3910.50	3494.80	12641.80
1966	4974.60	3742.40	3547.00	12264.00
1967	5378.40	4051.90	3849.80	13280.10
1968	5694.20	4290.90	4084.10	14069.20
1969	5770.30	4331.40	4143.20	14245.00
1970	0.0	0.0	0.0	0.0

Table A8. Value of the stock of farm machinery in constant (1957-59) million dollars, deflated by the index of prices paid for farm machinery

Year	ENC	WNC_I	WNC_{II}	NC
1939	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0
1945	3049.30	2072.00	1689.30	6810.70
1946	2410.70	1643.80	1395.40	5450.00
1947	2054.80	1405.80	1241.50	4702.00
1948	2416.10	1660.60	1526.20	5602.80
1949	2878.00	1978.60	1894.30	6750.90
1950	3382.70	2343.70	2236.90	7963.20
1951	3633.60	2548.70	2395.00	8577.30
1952	4158.50	2920.50	2742.50	9821.40
1953	4320.40	3049.60	2871.50	10241.50
1954	4567.30	3234.20	2023.60	10825.10
1955	4610.00	3290.80	3062.00	10962.80
1956	4590.00	3288.30	3051.50	10929.90
1957	4567.00	3287.90	3024.10	10879.10
1958	4349.20	3158.00	2901.60	10408.80
1959	4528.30	3302.90	2997.30	10828.50
1960	4485.40	3294.70	3012.20	10792.30
1961	4322.40	3189.80	2921.50	10433.80
1962	4332.10	3210.90	2919.00	10461.90
1963	4328.70	3213.40	2916.50	10458.60
1964	4477.60	3328.20	2992.30	10798.10
1965	4628.40	3456.40	3089.00	11173.90
1966	4375.60	3291.90	3120.00	10787.50
1967	4558.10	3433.90	3262.60	11254.60
1968	4686.60	3531.70	3361.40	11579.70
1969	4701.90	3529.40	3376.00	11607.30
1970	0.0	0.0	0.0	0.0

Table A9. Index of the ratio of prices received for farm products to prices paid for living expenses (a) (1957-59 = 100); index of prices received for farm products (b) (1957-59 = 100); U.S. unemployment rate (c)

Year	a[a]	b	c
1939	93.6	39.3	17.2
1940	97.7	41.4	14.6
1941	112.8	51.3	9.9
1942	126.2	65.8	4.7
1943	137.5	79.9	1.9
1944	133.1	81.5	1.2
1945	134.5	85.7	1.9
1946	138.1	97.7	3.9
1947	137.7	114.2	3.9
1948	135.2	118.8	3.8
1949	121.6	103.4	5.9
1950	124.0	106.8	5.3
1951	133.2	125.0	3.3
1952	125.6	119.2	3.0
1953	112.1	105.5	2.9
1954	107.7	101.8	5.5
1955	101.6	96.0	4.4
1956	99.2	95.2	4.1
1957	98.5	97.2	4.3
1958	103.0	103.4	6.8
1959	98.5	99.3	5.5
1960	97.0	98.5	5.5
1961	97.5	99.3	6.7
1962	97.8	101.0	5.5
1963	96.4	100.5	5.7
1964	93.4	98.1	5.2
1965	95.8	102.6	4.5
1966	99.8	110.1	3.8
1967	93.3	105.1	3.8
1968	92.1	108.0	3.6
1969	92.6	113.8	3.5
1970	90.4	115.8	5.6

[a]The ratio has been multiplied by 100.

Table A10. Hired (a), family (b) and total (c) farm labor in 1,000 workers in the United States. Value of the stock of farm machinery (d) in constant 1957-59 billion dollars (deflator: price index of farm machinery)

Year	a	b	c	d
1941	2652.0	8017.0	10669.0	8.29
1942	2555.0	7949.0	10504.0	9.58
1943	2436.0	8010.0	10446.0	11.13
1944	2231.0	7988.0	10219.0	11.90
1945	2119.0	7881.0	10000.0	13.19
1946	2189.0	8106.0	10295.0	10.60
1947	2267.0	8115.0	10382.0	9.19
1948	2337.0	8026.0	10363.0	11.01
1949	2252.0	7712.0	9964.0	13.36
1950	2329.0	7597.0	9926.0	15.73
1951	2236.0	7310.0	9546.0	16.90
1952	2144.0	7005.0	9149.0	19.36
1953	2089.0	6775.0	8864.0	19.98
1954	2081.0	6570.0	8651.0	21.06
1955	2036.0	6345.0	8381.0	21.29
1956	1952.0	5900.0	7852.0	21.14
1957	1940.0	5660.0	7600.0	21.20
1958	1982.0	5521.0	7503.0	20.21
1959	1952.0	5390.0	7342.0	20.93
1960	1885.0	5172.0	7057.0	20.76
1961	1890.0	5029.0	6919.0	19.91
1962	1827.0	4873.0	6700.0	20.01
1963	1780.0	4738.0	6518.0	20.01
1964	1604.0	4506.0	6110.0	20.79
1965	1482.0	4128.0	5610.0	21.38
1966	1360.0	3854.0	5214.0	21.90
1967	1253.0	3650.0	4903.0	22.34
1968	1213.0	3535.0	4749.0	23.17
1969	1176.0	3419.0	4595.0	21.82

Table A11. Annual wage rate per hired farm worker (a) in constant 1957-59 dollars; operator's realized income (b) (per farm) in constant 1957-59 dollars; price index of farm machinery (c) 1957-59 = 100; index of the ratio of prices received for farm products to prices paid for production expenses (d) (1957-59 = 100)

Year	a	b[a]	c	d[b]
1941	1035.1	2120.9	43.4	103.3
1942	1224.1	2705.7	45.9	116.4
1943	1432.2	3332.2	47.6	127.5
1944	1611.4	3294.7	48.7	123.4
1945	1703.2	3354.8	49.3	127.4
1946	1636.1	3589.8	51.0	133.8
1947	1479.9	3514.2	57.7	133.5
1948	1456.4	3124.6	67.2	124.4
1949	1465.0	2804.2	75.6	113.8
1950	1401.8	2644.6	77.6	113.6
1951	1392.7	2907.2	83.4	119.8
1952	1404.9	2865.6	86.2	113.9
1953	1391.1	2921.9	87.0	107.9
1954	1320.1	2648.7	87.4	104.5
1955	1359.1	2557.7	87.4	100.1
1956	1410.8	2748.7	91.3	99.7
1957	1427.8	2481.2	95.8	99.0
1958	1427.5	2930.8	99.9	102.6
1959	1464.7	2751.0	104.1	97.7
1960	1527.7	2918.2	106.9	97.3
1961	1546.5	3248.9	109.5	97.7
1962	1569.7	3316.2	111.4	97.9
1963	1610.5	3387.3	113.4	96.4
1964	1729.6	3621.0	115.9	95.1
1965	1794.9	3912.2	119.3	97.3
1966	1926.8	4575.0	123.8	101.1
1967	2038.0	4010.6	129.4	95.9
1968	2142.4	4101.5	135.5	96.8
1969	2212.1	4602.4	142.5	98.0

[a] Deflator: prices paid for living expenses.

[b] The ratio has been multiplied by 100.