9.

Market Structure for Family Labor in Agriculture[1]

THIS CHAPTER continues the analysis of labor markets in agriculture. The emphasis is on family labor. Family labor influences farm income in two fundamental ways: (a) as a resource it may influence total output and total income in agriculture, and (b) as an income unit it determines the number of ways total farm income must be divided. The focus and end-in-view of most agricultural policies has been to raise family farm income. Whether these policies are effective depends on the answers to several basic questions.

Whether or how soon a "free price" or another policy will raise farm income per worker to the nonfarm level depends on the responsiveness of farm family workers to a fall in relative income. Whether a government policy to raise farm income perpetuates the farm problem by retarding needed labor adjustments also depends on the nature of labor functions in agriculture. How farm labor mobility is influenced by nonfarm variables such as national unemployment and the nonfarm wage rate is one of the basic questions asked by individuals concerned with agricultural adjustment. The interrelationships of policies affecting national employment and farm labor mobility cannot be judged empirically without estimates of coefficients relating to the major economic variables in functions explaining family labor employment.

TRENDS IN LABOR USE RELATIVE TO PRICES, MECHANIZATION AND OTHER SUBSTITUTIONS

Persons employed in agriculture have been responding to relative prices of resources in about the manner expected from economic theory. Figures 9.1 through 9.4 illustrate the parallel decrease in total labor employment with the increase in price of labor relative to selected other inputs of agriculture. However, as explained in Chapter 8, several forces or variables relating to national and agricultural development are intercorrelated, and it is unreasonable to impute all, or perhaps even the major part, of a decline in the farm labor force to its rising price relative to other farm resources. These price relatives

[1]Stanley S. Johnson also is co-author of this chapter.

are obviously important, but also technological developments have shifted the capital-labor isoquants and have increased the marginal rate of substitution of capital for labor over time. Either change taken alone (increases in the relative price of labor or in the marginal rate of substitution of capital for labor) leads to substitution of capital for labor.

Figure 9.1 illustrates trends in ratios of (a) total family and hired

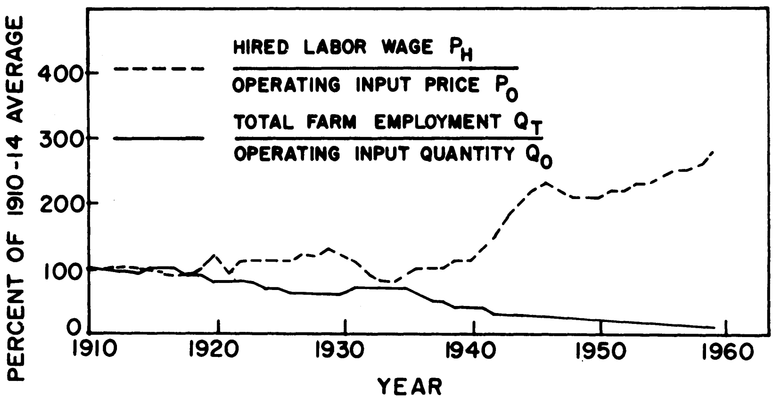

Figure 9.1. Ratios of farm labor and operating input prices and quantities from 1910 to 1959 (1910-14=100).

labor to operating inputs in agriculture and (b) farm labor price to operating input price. (The wage of hired farm labor is used here as an indication of labor price, although it does not serve perfectly for family labor.) Operating inputs include fertilizer, protein feed, seed, repairs and other nondurables. Both the relative quantity of labor and the price ratio remained somewhat stable from 1910 into World War I. After 1921, and except during the depression and immediately following World War II, the price of labor rose relative to the price of operating inputs and employment of labor in agriculture declined. Operating inputs and resources related to them were substituted for labor as a result of relative changes in these resource prices, and as a result of developments in technology.

Figure 9.2 compares the ratios of (a) total employment in agriculture to the quantity of machinery inputs and (b) the price of labor (hired farm wage rate) relative to farm machinery prices. (Machinery inputs are measured as the services necessary to maintain them at current levels.) The proportion of labor employed relative to machine inputs has declined rapidly, paralleling an increase in ratio of the price of farm labor relative to the price of farm machinery. While the price of farm labor has risen less relative to the price of farm machinery than for other farm inputs (i.e. the price of machinery has risen relative to the price of inputs such as chemicals, seed and feed), substitution of machinery for labor has been large over much of the period because of

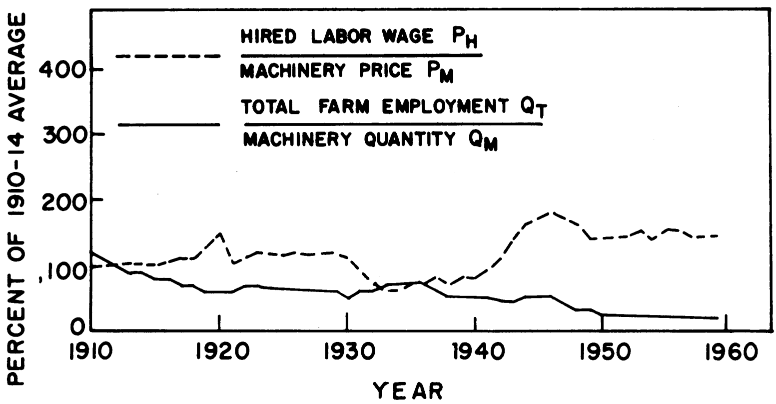

Figure 9.2. Ratios of farm labor and machinery prices and quantities from 1910 to 1959 (1910-14=100).

both the relative change in substitution rates and prices for machine inputs and labor. The continued substitution of machinery for labor during short periods when machinery price rose relative to labor price is a reflection of changes in substitution rates, perhaps as well as continued adjustments to previous price changes.

Figure 9.3 shows trends in the ratios of (a) labor used relative to land and (b) labor price relative to land price. Capital items have tended to substitute for both of these resources over time. Some substitution of land for labor, however, is indicated. (To an extent land also serves as a complement with machinery and other inputs in replacing labor. Farmers often buy higher capacity machinery, then add land to utilize it more fully.) The substitution of land for labor is not clearly indicated in response to the ratio of labor and land prices, perhaps partly because land return or price becomes a residual in the profitability of farming.

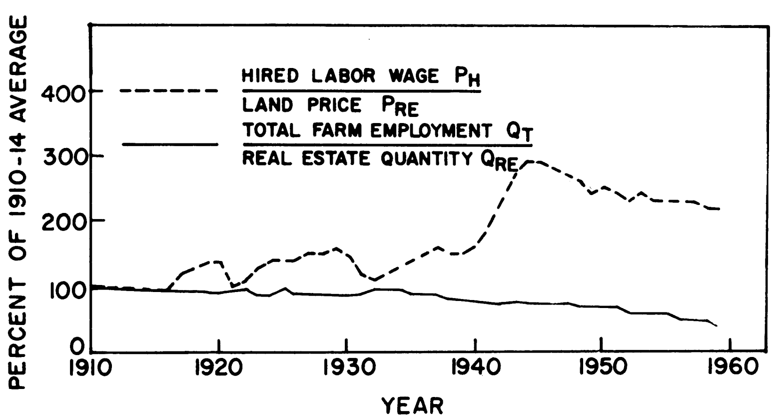

Figure 9.3. Ratios of farm labor and real estate prices and quantities from 1910 to 1959 (1910-14=100).

Figure 9.4 compares the ratios of (a) labor input to farm output and (b) labor price to prices received for crops and livestock. Labor input relative to crop output has declined as the labor/product price ratio has increased. The decline in input relative to output has been rapid especially since the 1930's. The decline in labor is expected theoretically, as an adjustment to increase marginal labor productivity following an increase in factor price relative to product price. Again, however, changes in technology increasing the rate at which labor is transformed into products, the low supply and demand elasticities of farm products and a decline in farm income accompanying a rapid increase in farm output, help to push labor out of agriculture.

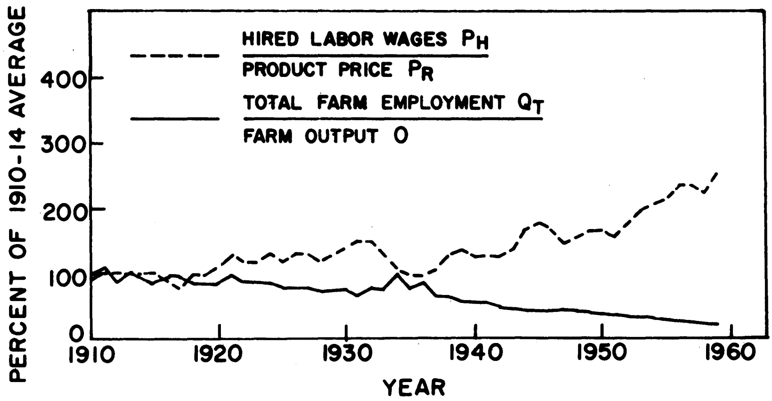

Figure 9.4. Ratios of farm labor and farm output prices and quantities from 1910 to 1959 (1910-14=100).

The data in Figures 9.1 through 9.4 suggest both direct and indirect relationships between employment of farm labor and relative prices of resources. Later sections include more detailed quantitative analysis of these and other interrelationships, with emphasis on family labor since it constitutes the major portion — 75 percent — of the farm labor force.

RELATIVE LABOR RETURNS

The number of family workers in agriculture decreased from 10.2 million in 1910 to 5.2 million in 1960. Since 1926 the number of family workers has declined at an average compound rate of 1.7 percent per year. Despite the rapid outmovement of workers, the per capita ratio of farm to nonfarm income remains low. The ratio was .43 in 1926, and was .47 in 1961.

Numerous hypotheses and propositions have been made to explain the continuous lag of labor returns in agriculture below returns in nonfarm employment. Some of the propositions are: (a) The existing ratio of farm and nonfarm incomes represents an equilibrium; real incomes being equal because of the psychic income in "farming as a way of life." (b) The ratio of returns as it exists represents an equilibrium, with equal returns for equal skills, because worker skills in agriculture are low. (c) Unionization of urban workers has reduced the mobility of farm workers and has perpetuated the disequilibrium income problem. (d) Mobility between regions is low and no serious disequilibrium exists between farm and nonfarm earnings in a given region. (e) Farmers are unaware of higher earning potential in alternative employments. (f) Farmers are responsive to wage differentials but unemployment in the urban sector has hindered farm labor mobility. (g) Farmers are responsive to wage (income) differentials but their responsiveness (elasticity) has not been great enough to cope with changes in farm structure. These changes in farm structure include output increasing (income decreasing) farm investment and technology.

Studies by Johnson provide some basis for rejecting hypotheses (a) to (d).[2] He states that it is necessary for per capita income of the farm population to be about 60 to 70 percent of the per capita income of the nonfarm population to have comparable real incomes. While it is reasonable to expect that in equilibrium some difference would exist between farm and nonfarm incomes due to psychic returns in the farm sector, the current discrepancy is too great to be explained by hypothesis (a). Johnson and Bishop[3] provide some data to reject the second hypothesis; namely, that skill capacities of rural workers are low. Based on actual earnings of farm migrants to urban areas and of urban nonmigrants, they conclude that average labor employed in agriculture has a labor capacity of approximately 90 percent of the labor capacity of urban and rural nonfarm populations for similar age and sex distributions. Differences in skills and earning capacities between farm migrants and nonfarm workers in urban areas tend to diminish with additional experience of farm workers on nonfarm jobs. These comparisons are, however, for farm workers who obtain positions comparable to laborers of nonfarm sources and do not entirely account for the fact that a greater proportion of unskilled farm laborers may be siphoned into the

---

[2]Johnson, D. Gale. Comparability of labor capacities of farm and nonfarm labor. American Economic Review 43:296-313. 1953; Farm prices, resource use and farm income. In U.S. Senate. Joint Economic Committee. Policy for commercial agriculture. pp. 448-58. Washington. 1957; Functioning of the labor market. Journal of Farm Economics 33:75-87. 1951; Labor mobility and agricultural adjustment. In Heady, Earl O., Diesslin, Howard G., Jensen, Harald R., and Johnson, Glenn L. Agricultural Adjustment Problems in a Growing Economy. Ch. 10. Iowa State University Press. Ames. 1958; The nature of the supply function for agricultural products. American Economic Review 40:539-64. 1950; Policies to improve the labor transfer process. American Economic Review 50:403-12. 1960; and Policies and procedures to facilitate desirable shifts of manpower. Journal of Farm Economics 33:722-29. 1951.

[3]Bishop, C. E. Economic aspects of changes in farm labor force. In Iowa State Center for Agricultural and Economic Development. Labor Mobility and Population in Agriculture. pp. 36-49. Iowa State University Press. Ames. 1961; The mobility of farm labor. In U.S. Senate. Joint Economic Committee. Policy for commercial agriculture. pp. 436-448. Washington. 1957; and Underemployment of labor in agriculture. Journal of Farm Economics 36:258-72. 1954.

lower end of the skill hierarchy. Johnson's work[4] also indicates that hypotheses (c) and (d) do not explain the full differential in incomes between agriculture and other industries. Unions have not been a serious obstacle to farm labor mobility in periods of low national unemployment. However, they may force a greater proportion of farm people, during periods of high unemployment, to have "little access" to the employment opportunities requiring seniority. Also differentials in income between farm and nonfarm sectors are found throughout the country. Sizeable gaps exist between returns from farm and urban employment in all low-income farming areas of the country. Also some mobility exists between sectors, and hypothesis (d) does not explain the failure of the gap between per capita incomes in agriculture and other industries to narrow.

EMPIRICAL ESTIMATES OF DEMAND FUNCTIONS FOR FAMILY LABOR

In this chapter two approaches are used to determine the market structure for family labor. One approach, to be considered later, is based on the hypothesis that net farm income is the relevant family labor "price" or decision variable.

The underlying hypothesis of this section, consistent with the demand functions previously estimated for hired labor, is that the demand for family labor is responsive to (a) the hired farm wage rate as an indicator of the price of family labor, (b) the index of prices received by farmers for all commodities as an indicator of the relative profitability of farming and (c) the price and/or quantity of farm machinery as a main substitute for labor. To complete the specification and as an indicator of farm technology, time has been included as a variable, along with the two price variables. In the model specification, the question arises as to the type of variable which adequately represents the "price" of family labor. The net return to the labor of a farm operator and his family is difficult to ascertain.[5] Some economists argue that the hired farm wage rate is an indication of the wage accruing to family labor.[6] For lack of a better indication of the return to family labor and to preserve comparability between hired and family labor estimates, the hired farm wage rate is used as the "price" of family labor in this section.

A demand function for total farm labor also was specified and estimated, as a means for comparison with the family labor demand functions. The model contains the following variables: the ratio of the

[4] Johnson, D. Gale. Policies and procedures to facilitate desirable shifts of manpower. op. cit.

[5] Ladd, George W. Farm income and the supply of agricultural products. Journal of Farm Economics 39:865-80. 1957.

[6] See: Douglas, Paul H. The Theory of Wages. The Macmillan Company. New York. 1934; and Fulmer, John L. Measurement of agricultural income of counties. National Bureau of Economic Research. Studies in Income and Wealth 21:343-57. 1957.

farm wage rate to the index of prices received, indicated as P_H; the index of the value of farm machinery deflated by the index of prices paid for living expenses by farmers, indicated as S_m; the index of prices received by farmers deflated by the index of prices paid (the parity ratio), indicated as P_R; and time T.

The family labor demand functions for the United States are included in Table 9.1 as equations (9.1) through (9.4). The periods for which the functions are fitted, the standard errors (in parentheses under regression coefficients) and the values of R^2 are included in Table 9.1, along with demand elasticities for P_H and P_R. (The subscript t indicates measurement of the variable for the current period and t-1 for the measurement lagged one year. See details on notation for labor in Chapter 8.) The predicted quantities for two of the family labor demand functions were plotted (figures not shown) against the actual numbers of family workers, and as expected, the functions for the more recent period, 1940-57, fitted the data better than those for the over-all period, 1910-57.

All regression equations presented are general single-equation least-squares estimates with original observations and are similar in specification for the different time periods. The sole difference between the equations is: the farm wage rate is lagged one year in equations (9.1) through (9.3). Since the number of family workers changes slowly over time, and because of estimation problems, the residuals may be autocorrelated. As an indication of autocorrelation, the d statistic for the Durbin-Watson test was computed for each of the four equations. The Durbin-Watson test for two of the equations (9.1 and 9.3) showed positive serial correlation, while test results in the other two (9.2 and 9.4) were indeterminate although time was included as a trend variable and was significant in all of the equations. The use of more refined techniques to help in eliminating autocorrelation was held to be unfeasible for this study.

Family Labor Demand in Relation to the Wage Rate and Farm Product Prices

Three of the four coefficients relating U.S. family labor employment to the farm wage rate were significant at a probability level of 95 percent with coefficients ranging in value from -.30 to -.93. There is some theoretical basis for lagging the wage rate in general least-squares equations. However, no advantage is indicated for such regression equations over the period 1940-57. For this period, equation (9.3) contained the wage rate lagged one year, while it was not lagged in equation (9.4). The regression coefficient in equation (9.4) was larger relative to its standard error than that of equation (9.3).

The demand for family labor is indicated to be responsive to changes in the farm wage rate. While all were inelastic, the price elasticities for the first three farm wage-rate variables were similar

Table 9.1. Regression Coefficients, Standard Errors (in Parentheses) and Elasticities of the Demand Functions for Family Labor, United States and Nine Geographic Regions*

Equation Number and Time Period	Region†	R^2	Code‡	Q_F t-1	P_N t	P_R t-1	S_m t	T
(9.1)	U.S.	.91	C	--	-.300	.040	--	-.629
1910-57			S		(.06)	(.04)		(.10)
			E		-.20	.03		
(9.2)	U.S.	.81	C	--	-.932	-.168	--	-.315
1920-39			S		(.12)	(.06)		(.07)
			E		-.16	-.11		
(9.3)	U.S.	.89	C	--	-.139	.313	--	-1.22
1940-57			S		(.11)	(.11)		(.33)
			E		-.14	.30		
(9.4)	U.S.	.95	C	--	-.878	.409	--	-.302
1940-57			S		(.20)	(.07)		(.07)
			E		-.32	.39		
(9.5)	NE	.87	C	.971	-.167	--	--	--
1940-57			S	(.12)	(.142)			
(9.6)	MA	.98	C	.908	-.303	.318	--	-.413
1929-57			S	(.12)	(.246)	(.23)		(.38)
			E		-.07	.07		
(9.7)	ENC	.87	C	.263	-2.71	1.93	--	4.08
1929-57			S	(.16)	(.71)	(.38)		(1.9)
			E		-.21	.02		
(9.8)	WNC	.75	C	--	-.155	--	-12.2	--
1929-57			S		(.51)		(2.0)	
(9.9)	SA	.98	C	.859	.605	.426	--	-8.08
1929-57			S	(.13)	(1.5)	(.962)		(3.41)
(9.10)	ESC	.94	C	--	-1.32	--	--	-39.1
1929-57			S		(2.3)			(4.4)
(9.11)	WSC	.92	C	--	-1.51	--	--	-35.7
1929-57			S		(1.85)			(5.43)
(9.12)	MTN	.96	C	.974	-.096	--	--	--
1929-57			S	(.08)	(.065)			
(9.13)	PAC	.98	C	.110	-.085	--	--	-5.94
1947-57			S	(.28)	(.26)			(1.52)

*The untransformed variables are:

Q_{Ft-1} = the number of family farm workers for the United States or by region as indicated, lagged 1 year.

P_{Ht} = the average hired farm wage rate for the United States or by region indicated, (lagged 1 year in equations (9.1) to (9.3).

P_{Rt-1} = the index of prices received by farmers for all commodities, United States for the national estimates, and the parity ratio for each region as explained under Table 8.6, lagged 1 year.

S_{mt} = the value of the stock of farm machinery and equipment, United States and regionally, as indicated.

T = time entered in linear form.

For the national estimates, P_H, P_R and S_m were deflated by the index of prices paid by farmers for production items, United States; for the regional estimates, P_H and P_R were deflated by the regional index of prices paid by farmers for living expenses.

†The identifying letters under the "Region" heading stand for the nine regions explained under Table 8.6, page 216.

‡C is the coefficient, S is the standard error and E is the elasticity, computed at the mean for the entire period.

in magnitude. The elasticity for (9.4) was somewhat larger. For the over-all period, 1910-57, given a 10 percent increase in the farm wage rate, ceteris paribus, the equations indicate an accompanying decrease in family labor employment ranging from 1.4 to 3.2 percent. There is no clear indication that the coefficients and elasticities have increased with time.

The response of family labor demand to prices received differed considerably for the time periods analyzed. For the period 1910-57, the regression coefficient and cross elasticity of demand approached zero. For two intervening periods the signs of the regression coefficients were different. The coefficient for the prices received variable was negative for the 1920-39 period and positive for the 1940-57 period. Further, both coefficients were statistically significant. The negative coefficient of P_R in equation (9.2) may result from some increase in the number of family workers over the 1920-39 period, along with a 10 percent decrease in the index of prices received. The depression, with a consequent lack of nonfarm opportunities, led to this situation during the 1930's. For the period 1940-57, as the index of prices received rose 10 percent, other things being equal, the demand for family workers decreased 3.5 percent. Since this period was one in which considerable off-farm work could be secured, the sign of the elasticity was also consistent.

Comparison of the Demand for Total Farm Labor With the Demand for Family Labor

A demand function for total farm employment was specified and estimated for the entire period, 1910-57, for comparison with the demand functions for family labor alone. The estimated total farm employment demand function is:

$$(9.14) \qquad Q_t = 156.14 - \underset{(.041)}{.013}(P_H/P_M)_{t-1} - \underset{(.103)}{.700}S_{mt-1} - \underset{(.039)}{.142}T - \underset{(.053)}{.205}(P_H/P_R)_{t-1}$$

The coefficient of determination for this equation is .95. In equation (9.14), the demand quantity of all farm labor is formulated as a function of the index of farm wage rates deflated by the index of farm machinery prices and lagged one year $(P_H/P_M)_{t-1}$, the value of the stock of machinery deflated by the price paid by farmers and lagged one year S_{mt-1}, time T and the farm wage rate deflated by the prices received by farmers for all commodities lagged one year $(P_H/P_R)_{t-1}$. In order to compare the results of the demand for total farm employment with a demand function for family labor, a demand equation for family labor was similarly estimated for the 1910-57 period. The resulting equation is:

$$(9.15)\quad Q_{Ft} = \underset{}{153.89} - \underset{(.065)}{.0821}(P_H/P_M)_{t-1} - \underset{(.162)}{.4338}S_{mt-1} - \underset{(.062)}{.1716}T - \underset{(.084)}{.1974}(P_H/P_R)_{t-1}$$

with a coefficient of determination of .86.

Equations (9.14) and (9.15) suggest that demand equations for family labor and hired labor may be similar. While differences do exist between the two equations, the coefficients lead to similar elasticity estimates. As the farm wage rate relative to prices received rose by 10 percent, there were corresponding average decreases in the total farm working force of 1.6 percent and in the family labor force of 1.5 percent. (Both of the corresponding regression coefficients were significant at the 95 percent level.) Response in demand for total and family labor to changes in the price of farm labor relative to farm output price was similar for the two functions.

The farm machinery variable, S_m, suggests the response of farm labor to additions in farm machinery in the previous year. As the investment in farm machinery rose by 10 percent in the past, there was a concurrent decrease of 3.1 percent in the total farm labor force, and 1.9 percent decrease in the family labor force. (Both of the corresponding regression coefficients were significant at a probability level of 95 percent or greater.)

The demand for total and family labor responded somewhat differently to changes in the variable, P_H/P_M, relating farm wage rates to farm machinery prices. The regression coefficients in both equations were nonsignificant at the 80 percent probability level. Both regression coefficients for the time variable, T, were significant and similar in size. Evidently, factors that could be explained by a linear trend were of similar importance to the two labor groups.

Regional Demand Functions for Family Labor

Regional demand functions for family labor are presented in Table 9.1 as equations (9.5) through (9.13). The demand functions for family labor for the regions were initially estimated by general least-squares methods. Because of inconclusive results in these first equations, distributed lag models were then applied for some regions. Since the distributed lag equations generally failed to improve the level of significance of the regression coefficients, demand equations using this model were not estimated for the remaining regions.

The regression coefficients for the farm wage rate variable ranged from -2.71 to .605 among regions. Only one of the regression coefficients was significant at the 95 percent level, however, and only in the distributed lag equations were the coefficients significant even at the 70 percent level. (Three regions had regression coefficients larger than their standard errors.) On the basis of this model formulation, the regional demand functions would indicate that the family labor force by region has not been particularly responsive to changes in the hired farm wage rate. Only in the East North Central region was the family labor force significantly responsive to the farm wage rate, the price elasticity being -.207. Since the other regression coefficients were not statistically significant, price elasticities were not derived for them.

The parity ratio was included as a variable in three of tne regional demand functions. Of the three regions, its regression coefficient was significant at the 95 percent level in the East North Central, 60 to 80 percent probability level in the Middle Atlantic, and significant only beyond the 60 percent level in the South Atlantic region. Because the parity ratio was included in only three of the nine regional demand functions for family labor, particular analysis is not made for this variable in the Northeastern region.

The third variable included in the regional demand functions for family labor was time in linear form. The time variable was significant at the 95 percent level in five of the six regional demand functions in which it was included. Of the regional demand functions in which time as a variable was either not included or was nonsignificant, three of the equations were estimated by a distributed lag model, the lagged variable being significant at the 95 percent level of probability.

Why are the coefficients for the United States demand functions for family labor significant while the corresponding regional coefficients generally are not significant? A possible answer may lie in the dominance of the trend variable in the regional demand functions and specification of a model which does not measure labor income of agriculture relative to nonfarm returns — since households which stay in agriculture and supply labor also demand this resource. If the data collected for each region does not reflect year-to-year marginal changes in the family labor force, then a trend variable would explain the smooth variations quite well. When the data are aggregated on a national scale, the accumulation of data may bring the year-to-year changes into greater prominence. (The time periods covered by the regional and national demand functions are different.) Also, we believe that the dominant force explaining the magnitude of family labor employment is the availability of nonfarm jobs relative to labor income in agriculture. In general, rapid migration of family workers has taken place in periods of ample nonfarm employment opportunities, even though the return to labor in agriculture has been high, or has temporarily increased relative to nonfarm wage returns. In contrast, migration has been low during periods of high national unemployment, even though relative returns in agriculture declined. Finally, both technological change and family labor migration have been rather continuous and "smooth" functions of time, causing complexities in relating demand for family labor to the price magnitudes mentioned in the previous section.

In the following section we attempt to improve the specification by (a) using residual farm income rather than hired wage rates as the "price" of family labor and (b) allowing for interdependence among farm and nonfarm variables. That is, a model is constructed that permits the response of family labor to income differentials to be conditioned by the rate of national unemployment in what essentially is a single reduced form function incorporating both supply and demand concepts.

Changes in demand and supply of farm labor have resulted in divergent migration patterns among regions according to Figure 9.5. Since 1940, net migration from agriculture has been greatest in low-income areas and smallest in some of the high-income and production areas of agriculture. Migration also has been high in areas of surplus products, e.g. the wheat areas of the Central Great Plains. The movement of people from farms has been highly selective among age groups. In general, out-migration has tended to be highest among young adults.

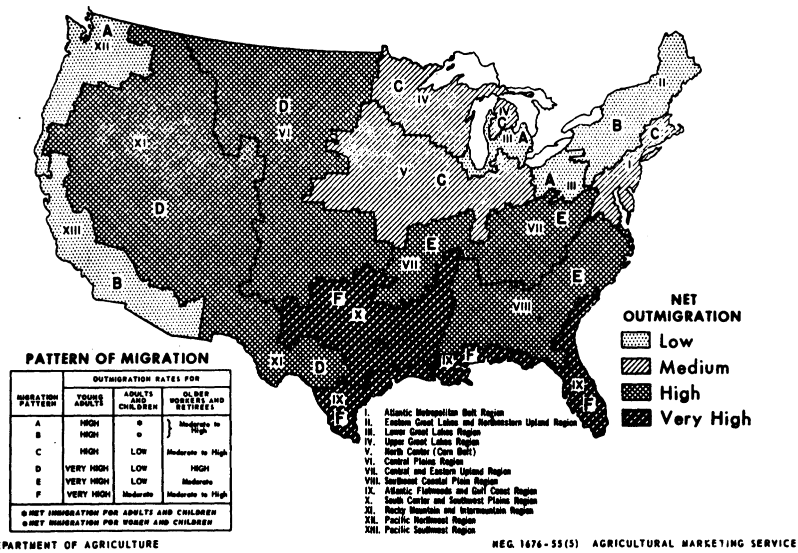

Figure 9.5. Net migration of the rural farm population by regions, 1940-60.

FARM EMPLOYMENT FUNCTIONS

We now turn to estimates which we prefer to call farm employment functions for family labor. One reason for doing so is because structural differentiation between the supply of and demand for family labor is difficult. We also use this distinction, from the functions estimated and certain ones to follow, because the specification of the demand structure is somewhat different.

Specification of the Family Labor Function

In this section we attempt to develop a flexible model of labor mobility to accommodate a fluctuating income and employment structure. The purpose is to obtain, from a function fitted to data extending over periods of heterogeneous employment and wage structures, reliable estimates of the influence of unemployment and other factors on labor mobility.

A single equation expressing the number of family workers as a function of earnings, unemployment and other variables appears logical for these purposes. Some justification for the single function is provided by the fact that the decisions to supply more manual labor or management, to migrate or not, in response to a favorable derived demand are made by the same individual. Too, the single endogenous variable, family employment in agriculture, is assumed to be a function of predetermined past income, financial position, machinery investment and of certain exogenous unemployment and nonfarm income variables.

In the previous section, in a manner similar to other studies, the hypothesis is examined that the hired farm wage rate, prices paid and prices received by farmers are the relevant family labor decision variables. In this section, residual farm income is used as the measure of the "price" of family labor. Family workers provide manual labor and entrepreneural (management and risk-taking) skills. The return or price for these services is implicit-not explicit. Because it is not possible to impute the amount of labor or return to each function of family labor, it is convenient to use residual net income as a combined measure of returns to family labor. The hypothesis is that family labor is not an out-of-pocket cost and, hence, market prices are not necessarily relevant. Whether the family worker stays on the farm is assumed to be, especially in the short run, a function of the residual income which remains to pay living expenses after production costs are paid. Although prices are unfavorable, this residual still may be sizeable because of improved farming efficiency, management or good weather. To consider the decision of a family worker to remain in agriculture as a function of farm prices received relative to the price of hired labor ignores the increased residual to family labor growing out of increased farming efficiency and other structural changes associated with improved entrepreneural skills. There also are definite statistical advantages, as well as limitations, in summarizing the many price and efficiency aspects into the single variable.

We first specify the number of family workers employed in agriculture, Q_F, as a function of the ratio of income per factory worker to income per farm worker, Y_R, the national unemployment rate, U, the farm equity ratio, E, forced farm sales, F, government programs, G, machinery investment, S_M, and slowly changing influences or time, T. The form and logic of the specification is given additional explanation below.

A "conventional" statistical model which might be employed is a simple linear function,

$$Q_{Ft} = a - bY_{Rt-1} + c\ U_{t-1} + d\ X \tag{9.16}$$

where X represents variables other than income and unemployment influencing Q_F. The negative coefficient of Y_R would indicate that as nonfarm income rises relative to farm income, Q_F will decrease as family workers take urban employment. An important aspect of labor mobility which creates unstable coefficients in linear equations such as above is the interaction between U and Y_{Rt-1}. The rate, b, at which a given income ratio moves workers off farms is subject to the rate of national unemployment. To account for this structure, an interaction variable $Y_R(1-U)$ is added to equation (9.16) to form equation (9.17).

$$Q_{Ft} = a - b\ Y_{Rt-1} + c\ U_{t-1} + d\ X - e\ [Y_R(1-U)]_{t-1} \tag{9.17}$$

Combining the two terms containing income, the coefficient of Y_R is $-b - e\ (1-U)$ and obviously is a function of the level of unemployment.

Equation (9.17) is modified slightly to conform to certain a priori considerations. There is some doubt whether unemployment U shifts the level of family labor of itself, irrespective of income and other ininfluences. To correct for this, the variable U_{t-1} is omitted. Second, it is likely that if U reaches some level, the coefficient of relative income becomes zero. The implication is that when national employment reaches some critical level, V, a low relative income in agriculture no longer is effective in adjusting employment to equilibrium levels. Under these circumstances, average incomes are not a useful economic indicator. At the margin, Y_R is zero because the marginal nonfarm income is zero for the unemployed factory worker (assuming no unemployment compensation). If the signs of the coefficients are as indicated in equation (9.17), the coefficient of Y_R approaches -b as U approaches one. This critical value is too high, and equation (9.17) is modified in two ways to accommodate a lower value. The first is to assign different values of V in the interaction term. The equation then is

$$Q_{Ft} = a - b\ [Y_R(1-U/V)]_{t-1} + d\ X. \tag{9.18}$$

It is apparent that when U equals V, b equals zero. The variable within brackets may be constructed for several values of V until one is found by trial and error giving the highest R^2. The variable is constructed to equal zero when U is greater than the assigned value of V, the assumption being that b may be zero but not positive.

If we allow b to be positive or negative, the trial and error method for finding V in equation (9.18) may be replaced by a noniterative scheme. The case for a positive coefficient b when U is larger than V is supported by the growth in numbers of agricultural workers during the depression. If the necessary statistical assumptions also are met, the following model will also give the best linear unbiased estimate of

V. The model is formed by multiplying the terms within the brackets of equation (9.18) by b. The result is

$$(9.19) \qquad Q_{Ft} = a - b\, Y_{Rt-1} + \frac{b}{V} (UY_R)_{t-1} + d\, X.$$

It is apparent that the critical unemployment level V at which relative income no longer is effective in drawing workers from agriculture is readily computed from the coefficient of UY_R. Equation (9.19) does not restrict the value of b; the coefficient becomes positive when U is greater than V. This conforms with historical experience since during the depression of the 1930's there was a net migration into agriculture. The greatest potential influence of Y_R on Q_F is indicated by b. That is, the coefficient of Y_R is the maximum negative value b only when unemployment is zero. The logic of the model of income and unemployment depicted in equation (9.19) is appealing and is the foundation for several fitted equations which follow.[7]

The Variables

The "X" variables in equation (9.19) need further explanation. These variables are investment stock of farm machinery, S_M, the equity ratio, E, percentage of forced (bankruptcy) sales, F, government programs, G, and slowly changing influences, T. If farmers are in a favorable financial position because of inflated land or other values or because past income has been greater than expenses, it is reflected in the ratio of proprietors' equity to liability. E is a measure of long-term financial success and ability to withstand the vicissitudes of short-run income fluctuations. If E is high, farmers may be able to withstand short-run income reverses by utilizing financial reserves obtained in the past.

Investment in machinery is somewhat both output increasing and cost increasing for a given number of workers. Due to the inelastic demand for farm products, these influences of machinery are reflected in residual farm income. It might be argued that machinery investment need not be specified separately in the labor function because the

[7] Other, nonlinear assumptions about the relationship between unemployment and relative incomes may be appropriate. One is to assume a model of the form

$$\text{(a)} \qquad Q_F = a\, Y_R^{-b(1-U/V)}\, X^c.$$

It may be estimated by least squares as a linear function

$$\text{(b)} \qquad \log Q_F = \log a - b \log Y_R + \frac{b}{V} (U \log Y_R) + c \log X.$$

Another suggested model is

$$\text{(c)} \qquad Q_F = a - b\, Y_R\, (1 - U^2/V) + c\, X$$

and would be estimated by ordinary least squares as

$$\text{(d)} \qquad Q_F = a - b\, Y_R + \frac{b}{V} (U^2\, Y_R) + c\, X.$$

laborsaving feature does not of itself reduce family employment. (Workers need only work fewer hours and receive the same income.) There exists an important indirect reason for specifying an investment effect other than that reflected in farm income. Although farm income is favorable, some workers will migrate because of high capital requirements, or because they are not needed on highly mechanized farms.

The following variables, undoubtedly, have influenced family labor mobility, but cannot be specified separately in the labor function. The slowly changing trend variable, T, reflects, although imperfectly, some of these factors such as education, transportation and communication. The influence of economies of scale and consequent pressures for larger and fewer farms also may be embodied in the time variable.

When farm incomes become very low, the "smoothly" functioning labor market breaks down as farmers become bankrupt. To accommodate this changing structure, a variable indicating the percent of forced sales is included in the labor function. The family farm operator who has lost his farm may become a hired farm laborer if he cannot find employment in a depressed urban economy, and the other variables in the function may not adequately represent these effects.

The influence on labor mobility of government policies shifting farm income is measured to some extent by Y_R. But other indirect influences of legislation may be specified separately. For example, land retirement policies may have a direct effect not reflected in Y_R, and are indicated by a separate institutional variable, G.

Finally, if adjustments to relative income, machinery investment and other explanatory variables are made slowly, the lagged employment variable Q_{Ft-1} can be specified in the labor function to estimate the adjustment coefficient.

It might be contended that an improved farm financial position indicated by a low value of Y_R or a high value of E facilitates labor mobility by providing capital for moving. The fact that outmovement of family laborers has been more rapid from low-income farm areas than from high-income farm areas provides a sufficient basis for rejecting this hypothesis. This does not preclude the hypothesis, however, that favorable agricultural earnings reduce the number of agricultural workers in the long run by providing funds for laborsaving farm mechanization.

The variables in the family labor or employment function are defined specifically as follows:

Q_{Ft} = the dependent variable which is the number of family workers employed in agriculture during the current year, measured in 10 thousands.

Y_{Rt-1} = an index of the ratio of the average annual wage per employed factory worker to the residual farm income per family worker in agriculture in the past year. Residual farm income is gross farm income, including government payments and nonmoney income, less production expenses including hired labor. The index is expressed as a percent of the 1947-49 period.

U_{t-1} = the percentage of the national labor force unemployed during the past year, unadjusted for seasonal variation. When specified with income as UY_R, the unemployment variable is expressed as a proportion rather than a percent.

E_{t-1} = the past year ratio of proprietors' equity to liabilities in agriculture.

F_t = the percentage of farm sales forced through bankruptcy in the current year.

G_t = an index of government policies. Years when acreage allotments or production controls are in force are given the value -1. Years when farm prices are supported are assigned values of +1. If supports are fixed, an additional +1 is added. The values are summed to form the index G.

S_{Mt} = the stock of all productive farm machinery on farms January 1 of the current year.

T = time, an index composed of the last two digits of the current year.

All the above variables are annual data for the U.S. from 1926 to 1959, omitting 1942 to 1945. Some of the variables were not recorded prior to this period. While there would be obvious advantages in analyzing the labor function for various segments of the 1926-59 period, the data are not considered adequate for such refinements.

Family Labor Equations Estimated by Least Squares

The six explanatory variables in equation (9.20) of Table 9.2 explain a large proportion of the annual variation in the quantity of family labor employed on farms. Two variables, F and G, contribute little to the explanation, however. The results indicate that there has been a nonsignificant direct effect of government programs, G, and forced (bankruptcy) sales, F, on labor mobility not reflected by other variables such as Y_R and E. In equation (9.21) the beginning year stock of machinery, S_M, is substituted for these variables. The standard error is twice the coefficient of the machinery variable, however. For this reason, S_M is excluded in equation (9.22). The four independent variables in equation (9.22) explain 98 percent of the variation about the mean of Q_F. The coefficient of Y_R is significant at the 95 percent probability level; the other coefficients are significant at the 99 percent level. All coefficients display the expected signs, and the test for autocorrelation in the equation is inconclusive.

If E is omitted and F and G are included as in equation (9.23), the

Table 9.2. Functions for Family Labor Q_F Estimated by Least Squares With Annual Data From 1926 to 1959, Excluding 1942 to 1945; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation	R^2	d†	Constant	Y_R t	UY_R t	Y_R t-1	UY_R t-1	E t-1	S_M t	F t	G t	T	Q_F t-1
(9.20)	.979	1.16	1344			-.50	3.32	19.31		.71	-.47	-15.27	
						(.25)	(.67)	(5.03)		(.99)	(.94)	(1.08)	
(9.21)	.979	1.10	1367			-.40	3.30	16.01	-.0022			-14.97	
						(.31)	(.83)	(2.75)	(.0046)			(1.34)	
(9.22)	.978	1.14	1385			-.50	3.60	16.07				-15.52	
						(.24)	(.54)	(2.70)				(.70)	
(9.23)	.966	.86	1469			-.75	4.33			-1.19	2.13	-14.04	
						(.30)	(.77)			(1.08)	(.82)	(1.30)	
(9.24)	.983	1.10	1455	-1.16	4.69			11.74				-14.63	
				(.19)	(.47)			(2.12)				(.60)	
(9.25)‡	.990	-‡	-‡	-.56	2.22			1.79				-1.41	
				(.18)	(.60)			(2.66)				(1.19)	
(9.26)	.989	1.40	324			.25	.30	7.90				-5.13	.74
						(.23)	(.78)	(2.58)				(2.19)	(.15)
(9.27)	.993	1.68	671	-.48	2.29			7.43				-7.43	.54
				(.18)	(.52)			(1.61)				(1.33)	(.10)

*The dependent variable Q_F and the indicated independent variables are defined in the text. All equations are linear in original values. For exact sources of each variable, and for values of the R^2 adjusted for degrees of freedom see: Tweeten, Luther G. An economic analysis of the resource structure of U.S. agriculture. Unpublished Ph.D. Thesis. Library, Iowa State University. Ames. 1962.

†The Durbin-Watson autocorrelation statistic d.

‡Estimated by least squares with a first-order autoregressive transformation. The first-order autoregressive coefficient was estimated to be .92, the standard error .09. The Durbin-Watson autocorrelation statistic and constant terms were not computed for the autoregressive equation. All results in the table are based on the model presented in text equation (9.19).

coefficient of G is positive and significant. If taken seriously, the inference is that government programs have significantly influenced family labor mobility. The inconsistency of the results in equations (9.20) and (9.23), and the crude formulation of the variable G, suggests that the extent of the direct influence of government programs on labor mobility cannot be determined from the equations in Table 9.2.

When current rather than past income and employment variables are included in the labor function, the magnitude and significance of the coefficients of Y_R and UY_R are increased. The R^2 also is greater in equation (9.24) than in equation (9.22). Statistically, equation (9.24) is preferable, but logically equation (9.22) with lagged variables is desirable. It is expected that at least a 1-year lag is required for farmers to adjust to a change in relative incomes.

The relatively low values of d cast doubt about the randomness of the residuals in equation (9.24) and previous equations. For this reason equation (9.24) is estimated assuming the residuals follow a first order autoregressive scheme.[8] Autoregressive equation (9.25) is estimated

[8] The assumption is that the residuals are formed by a Markov process, i.e.

(a) $$u_t = B\, u_{t-1} + e_t$$

where u_t is the current residual and e_t is randomly distributed. In equation (9.25) the residual is found by an iterative process described in Chapter 8, and is

(b) $$u_t = \underset{(.09)}{.92}\ u_{t-1} + e_t.$$

with the assumption that the current residuals are a linear function of the residuals in the past year plus a random element. The transformation resulted in a first order autoregressive coefficient of .92 with a standard error of .09. The highly significant coefficient obviously has absorbed the time trend in equation (9.25). The autoregressive transformation (and time, T) essentially is a substitute for other variables which cannot be specified individually in the equation. Whether the time trend is reflected in the autoregressive scheme or by the time variable itself does not necessarily lead to a different interpretation. Either result is an indication of our inability to specify more exact variables, and we can only postulate what influences either represents. Analysis of employment numbers suggests a strong basis for a time trend not adequately explained by the independent variables. Equation (9.25) adds little to our knowledge of labor mobility, and the following discussion of equations (9.26) and (9.27) indicates that the autoregressive transformation may not be appropriate. Thus, inferences of the nature of family labor mobility in subsequent pages are based on other equations in Table 9.2.

Equations (9.26) and (9.27) are estimated with a distributed lag to allow a gradual adjustment to equilibrium. The results using the current rather than past income and employment variables are more acceptable. Certain considerations suggest that inclusion of the lagged employment variable completes the specification. First the coefficient of the variable is significant and the R^2 is increased. Second, the autoregressive transformation applied to equation (9.27) (the equation is not included) resulted in a nonsignificant first order coefficient of .58 with a standard error of .33. The R^2 was not increased by the transformation. A highly nonsignificant F test for the contribution of the autoregressive transformation to the explanation of employment suggests that introducing the autoregressive scheme only realigned coefficients and did not improve the explanation. The coefficients of income, employment and Q_{Ft-1} remained nearly the same, but the coefficients of E and T were reduced substantially by the autoregressive form of equation (9.27). A third reason for supposing that addition of Q_{Ft-1} completed the specification is the similarity of the coefficients of Y_R and UY_R in equations (9.26) and (9.27). The implication is that the autoregressive scheme "substituted" for Q_{Ft-1} in equation (9.25). It is not possible, of course, to infer from this that the autoregressive transformation always will substitute for an incomplete specification. The short-run coefficients of Y_R and UY_R may be more consistent after the autoregressive transformation in equation (9.25), but without knowledge of the correct structure, inferences about the long-run coefficients would be incorrect. The long-run labor function is found by dividing the coefficients in equation (9.27) by the adjustment coefficient 1 - .54 = .46. If this division is made, it is interesting to observe that the long-run coefficients are very similar to the coefficients of equation (9.24), estimated without the lagged employment variable.

The R^2 is .99, the coefficients meaningful and significant; thus equation (9.27) appears to be a useful expression of the family labor function. Some instability is introduced by the high simple correlation ($r = .94$) between T and Q_{Ft-1}. Other simple correlations among explanatory variables are less than .90 in equation (9.27).

To help resolve the question of the importance of current and past price and employment variables posed in Table 9.2, the specification of the family labor function is modified slightly. Assume that decisions to seek alternative employment are based on expected relative income. The expected income is likely to be based primarily on past income, because current income is not known until late in the year. If expected income is favorable, the ultimate and final decision to change jobs may depend on current unemployment. This reasoning leads to specification of variables Y_{Rt-1} and $U_t Y_{Rt-1}$ in the family labor function. The resulting least-squares equation is:

$$(9.28)\quad Q_{Ft} = 1407 - \underset{(.29)}{.86}Y_{Rt-1} + \underset{(.64)}{4.27}(U_t Y_{Rt-1}) + \underset{(2.82)}{12.70}E_{t-1} - \underset{(.73)}{14.57}T$$

$$R^2 = .979 \qquad d = 1.19.$$

In some respects this equation is an improvement over equation (9.22). The R^2 is slightly higher and the magnitude and significance of the coefficient of Y_{Rt-1} is greater. Also, the degree of autocorrelation, indicated by d, is somewhat less in equation (9.28). The importance of current and price variables is not completely resolved, however. To avoid misinterpretation, coefficients of either current or past income and employment variables are labeled "short run."

Table 9.2 was comprised entirely of equations patterned after the model in (9.19). Table 9.3 illustrates alternative specifications of the family labor function based on the variables found most useful in Table 9.2. The important impact of national unemployment on labor mobility is illustrated more clearly in equation (9.29). The number of family laborers is specified as a conventional simple linear function of Y_R, U, E and T. (Cf. equation (9.16)). The coefficient of Y_R is nonsignificant and the sign is opposite that expected. Yet the coefficient of determination is larger than for several equations in Table 9.2. Addition of the interaction term in equation (9.30) reverses the sign on the coefficient of Y_F, but neither the coefficient of Y_F nor of $Y_F(1-U)$ is significant. (Cf. equation (9.17)). It is probable that an F test for the joint influence of the two variables containing Y_R would be significant. Thus, equation (9.30) does not necessarily lead us to accept the hypothesis that relative incomes are unimportant in determining the level of family employment.

Equations (9.31) to (9.34) are included to illustrate the results of using several critical unemployment values V. (Cf. equation (9.18)). The income-employment variable $Y_F(1-U/V)$ is constructed to equal zero when U is greater than V. For convenience the critical value is given as a reciprocal in Table 9.3. That is, for $Y_R(1-3U)$, $V = .33$; for

Table 9.3. Alternative Functions for Family Labor Q_F Estimated by Least Squares With Annual Data From 1926 to 1959, Excluding 1942 to 1945; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation	R^2	d†	Constant	Y_R t	U t-1	Y_R(1-U) t-1	Y_R(1-3U) t-1	Y_R(1-5U) t-1	Y_R(1-5U) t	Y_R(1-7U) t-1	E t-1	T	Q_F t-1
(9.29)	.984	1.07	1285	.19	6.40						22.43	-16.52	
				(.14)	(.76)						(2.31)	(.60)	
(9.30)	.986	1.04	1212	-1.83	10.49	2.56					16.69	-17.19	
				(1.45)	(3.01)	(1.82)					(3.79)	(.76)	
(9.31)	.916	.24	1295			.68					13.99	-15.56	
						(.38)					(5.20)	(1.36)	
(9.32)	.954	.78	1517				-1.34				6.84	-14.47	
							(.26)				(2.95)	(.97)	
(9.33)	.975	.79	1443					-.95			13.35	-15.24	
								(.11)			(2.27)	(.71)	
(9.34)	.970	.58	1430							-.90	14.50	-15.47	
										(.12)	(2.55)	(.79)	
(9.35)	.993	1.36	750						-.59		8.19	-8.20	.49
									(.11)		(1.65)	(1.38)	(.10)

*Sources and composition of the dependent variable Q_F and of the indicated independent variables are discussed in the text. All equations are linear in original values.

†The Durbin-Watson autocorrelation statistic d.

$Y_R(1-5U)$, V = .20; and for $Y_R(1-7U)$, V = .14. When V = 1.00 in equation (9.31), the coefficient of the income-employment variable has the wrong sign and is not significant, the R^2 is relatively low and autocorrelation in the residuals is highly significant. As V is decreased to .20, the R^2 increases, the degree of autocorrelation in the residuals declines and the significance of the coefficient of the income-employment variable increases appreciably. The results indicate that V approximately is 20 percent unemployment, a quantity corresponding to the arbitrary value selected for similar equations for hired labor in Chapter 8.

Equation (9.35), estimated with a distributed lag, and assuming V equals .20, explains 99 percent of the annual variation about the mean of Q_F. All coefficients have the expected signs and are highly significant. The estimated adjustment coefficient, .5, is the same as that estimated in equation (9.27), Table 9.2. The distributed lag model appears to be a useful formulation of the family labor function. It may be noted that the long-run coefficients of E and T, found by dividing the short-run coefficients by the adjustment rate .5 in equations (9.27) and (9.35), are nearly equal to the coefficients of E and T in equations (9.20) to (9.24) and (9.29) to (9.34).

Income Elasticities

The elasticities of family labor movements with respect to relative incomes are illustrated in Table 9.4 for selected equations from Tables 9.2 and 9.3. The results indicate that the short-run (one or two years) response to relative incomes is low and is sensitive to the level of unemployment. The maximum short-run elasticity (zero unemployment) probably is no greater than -.1 according to the data of Table 9.4. The implication is that a 10 percent decline in farm income relative to income of factory workers could decrease the number of family workers up to 1 percent in the short run. But if unemployment were 15 to 20 percent, a 10 percent decline in relative farm income would have no effect on the number of family workers in agriculture. Thus, the short-run response of Q_F to relative incomes is low when national unemployment is low and is negligible when unemployment reaches 15 to 20 percent according to Table 9.4.

The long-run response of family workers to changes in relative incomes is considerably greater than the short-run response. In the long run the farmers' financial situation, indicated by the equity ratio E, deteriorates with a low farm income. The result is that the long-run elasticity with respect to farm income may be as high as .36 according to equation (9.35).[9] Because the interrelationship between labor

[9] The elasticities computed from equation (9.28) are not included in Table 9.4 although the equation has certain logical and statistical advantages. The short-run elasticities computed from equation (9.28) are slightly greater than those computed from equations (9.22), (9.27) and (9.35). The long-run elasticities computed from equation (9.28) are less; the maximum long-run elasticity for U = .05 is .27 compared with .34 and .35 based on equations (9.27) and (9.35).

Table 9.4. Elasticities of Family Labor Q_F With Respect to Farm Income per Family Worker Y_F' and Factory Income per Worker Y_N Estimated at the Mean From Equations in Tables 9.2 and 9.3

Unemployment (Percent)	Equation (9.22) Short run (1-2 years) Y_R *	Equation (9.22) Long run (4-6 years) Y_F'†	Equation (9.27) Short run (1-2 years) Y_R *	Equation (9.27) Long run (4-6 years) Y_N‡	Equation (9.27) Long run (4-6 years) Y_F'§	Equation (9.35) Short run (1-2 years) Y_R *	Equation (9.35) Long run (4-6 years) Y_N‡	Equation (9.35) Long run (4-6 years) Y_F'§
0	-.089	-	-.087	-.189	-	-.107	-.208	-
5	-.057	.25	-.067	-.144	.34	-.080	-.156	.35
10	-.024	.22	-.046	-.099	.30	-.054	-.104	.30
15	.008	-	-.025	-.054	-	-.027	-.052	-
20	.041	-	.004	.008	-	.000	.000	-
25	.073	-	.017	.037	-	.000	.000	-
1926-59 average (9 percent)	-.031	.23	-.050	-.108	.31	-.059	-.114	.31
1946-59 average (4 percent)	-.063	.26	-.071	-.153	.35	-.086	-.166	.36

*The short-run elasticities with respect to Y_R. Since $Y_R = Y_N/Y_F'$, the short-run elasticities with respect to Y_R, Y_N and $-Y_F'$ are equal.

†The long-run elasticity with respect to farm income, Y_F, is the short-run elasticity .057 (for U = 5 percent) plus the elasticity with respect to E. The elasticity of Q_F with respect to E is .126. A sustained 1 percent increase in Y_F' is expected to raise E approximately 1.57 percent. The total long-run elasticity with respect to Y_F' roughly is .057 + (.126)(1.57) = .25 when unemployment is 5 percent. Because the elasticity with respect to E is not adjusted adequately for U, it is only estimated well within the range of the average U from historical experience.

‡The short-run elasticity with respect to Y_R divided by the adjustment coefficients .46 in equation (9.27) and .52 in equation (9.35). The long-run elasticity with respect to Y_N is much less than with respect to Y_F' because Y_N does not influence E.

§The long-run elasticity with respect to Y_F' is the short-run elasticity .067 (for U = 5, equation (9.27)) plus the long-run Y_F' component of E, or .091, divided by the adjustment coefficient .46. The total elasticity is, therefore, (.067 + .091)/.46 = .35. Similar computations are made for equation (9.35). The long-run elasticity with respect to Y_F' is much greater than with respect to Y_N because a reduction in the former affects farm equity. The magnitude of the adjustment coefficient .5 indicates that slightly over three years are required to make 90 percent of the total adjustment after the explanatory variables have changed. Because the explanatory variables do not change immediately, one to three years are added to the three-year adjustment indicated in the equation.

mobility, unemployment and a change in equity E was not stressed in the empirical analysis, it is not feasible to estimate the response to a change in E for values of U other than 5 and 10 percent. That these unemployment rates are quite realistic and well within the range of historical experience is indicated by the average unemployment in the 1926-59 and 1946-59 periods in Table (9.4). It seems reasonable that the long-run response to a given income differential is less conditioned by the level of unemployment than is the short-run response. Given time, family workers can filter into scattered nonfarm jobs despite high general unemployment.

The long-run elasticity of Q_F with respect to a change in the nonfarm income Y_N may be as high as -.21 according to equation (9.35). The long-run elasticity with respect to Y_N is lower than with respect to Y_F' because a sustained drop in farm income leads to a weakening of the farm financial position. Eventually the farmer may not be able to meet fixed financial obligations, and loan foreclosure or other difficulties may result. To summarize, a 10 percent fall in farm income is predicted to decrease the number of family workers up to 3.5 percent in the long run. A 10 percent rise in nonfarm incomes may decrease the number of farm family workers as much as 2 percent. But if unemployment is high, the response of workers to a change in income may be much lower than these estimates according to Table 9.4.

The elasticity estimates are from data covering a period of falling family employment and relative farm income. The results, therefore, are relevant for such conditions, and it is hazardous to gauge the impact of large increases of farm income on employment from the data of Table 9.4.

Table 9.4 emphasizes the important interaction between the rate of unemployment and the income elasticities. The critical level, V, at which elasticities reach zero for equation (9.22) is .14, equation (9.25) is .25, equation (9.27) is .21, equation (9.28) is .20 and for the trial and error equations (9.31) to (9.34) is .20. In several depression years, national unemployment equaled or exceeded the critical value indicated by the above equations. Unemployment of 3 percent of the national labor force is consistent with seasonal and frictional labor adjustments. Equation (9.22) indicates that the short-run effectiveness of relative incomes in bringing adjustments in the farm labor force is decreased 25 percent when unemployment increases from 3 percent to 6 percent (unemployment in some years has been 6 percent or slightly greater). The results emphasize the close economic relationship between the farm and nonfarm sectors. They also emphasize that a government policy encouraging high national employment also facilitates adjustments in agriculture.

Shifts in the Family Labor Function

The number of family workers in agriculture declined 43 percent from 1926 to 1959, or at an average compound rate of 1.7 percent per year. Some of the forces responsible for this change may be evaluated from the foregoing labor functions. A measure of the relative influence of income, equity and time on the number of workers may be judged by the standard partial regression coefficients. If U equals zero, the standard partial regression coefficients of equation (9.22) are -.16 for Y_R, .39 for E and -1.15 for T.[10] If U equals 14 percent, the standard partial

[10] The standard partial regression coefficient b_i' is computed as

$$\text{(a)} \qquad b_i' = b_i \sqrt{\frac{\sum x_i^2}{\sum y^2}}$$

where b_i is the multiple correlation coefficient, $\sum x_i^2$ is the corrected sum of squares for independent variable X_i and $\sum y^2$ is the corrected sum of squares for the dependent variable. The standard partial regression coefficients are corrected for the estimated differences in variances and are intended to reflect the relative influence of the independent variables on Y. They are somewhat comparable to the usual estimates of elasticities E_i of Y with respect to X_i computed at the means, i.e.,

$$\text{(b)} \qquad E_i = b_i \frac{\bar{X}_i}{\bar{Y}.}$$

The elasticities are corrected by the ratio of the means; standard partial regressions by the square root of the ratio of estimated variances.

regression coefficient of Y_R is zero. The results indicate that the relative influence of Y_R on Q_F tends to be small and is overshadowed by E and T even with high national employment. If U equals zero, the actual coefficient of Y_R is -.86 and of T is -14.57 in equation (9.22). The index of relative incomes Y_R would have to fall 17 points in one year to decrease Q_F in the short run as much as forces associated with the time variable. This result and the foregoing elasticity estimates provide support for the hypothesis that the responsiveness of farm employment to a change in relative earnings is not great enough to cope with the large adjustments necessary to equate earnings in the farm and nonfarm sectors.

The actual change in Q_F for a given period of time depends on the trend in the variables as well as on the relative impact of a given variable on Q_F. Equation (9.22) predicts a total decline, over the period analyzed, of 42 percent in the family labor force; the actual decline was 43 percent. The value of Y_R was nearly the same in 1926 as in 1959. Even if the coefficient of income were large, it would not explain the decline in Q_F from 1926 to 1959. Ceteris paribus, the improvement in equity E from 1926 to 1959 would have increased Q_F by 8 percent according to equation (9.22). It is apparent that nearly the entire decline in Q_F is associated with the time variable T. The results suggest that the family labor force has decreased approximately 150,000 per year due to factors associated with this variable. The result is based on the coefficients of T in equations (9.20) to (9.25), (9.28) and (9.29) to (9.34). (This result also agrees with the long-run coefficients of equations (9.22) and (9.35).)

EMPIRICAL ESTIMATES OF NATIONAL SUPPLY FUNCTIONS FOR FAMILY LABOR

This section includes direct empirical estimates of supply functions for family labor in the United States. Paralleling equations (9.1) through (9.15), the hypothesis is tested that the supply of farm labor is responsive largely to changes in the farm wage rate and the nonfarm wage rate. The foregoing analysis of the equations (9.16) through (9.36) pull the hypotheses in the direction of selected other variables. However, the latter variables have not been included in the analysis of farm labor supply (since the supply analysis was made prior to that of the previous employment section). However, the first of the equations presented in this section might also be "looked upon" as farm labor employment equations, while later equations of the section are "migration" equations. This hypothesis is related to quantification of the "push-pull" migration theory: the assumption that the rate of off-farm migration, which directly affects the supply of farm labor, is subject more to the "pull" of nonfarm wage rates and employment opportunities than to the "push" of the introduction of laborsaving machinery and techniques.[11]

The analysis of the supply functions for hired labor in Chapter 8 does not necessarily reflect the relationship of the variables specified to the supply quantity of all farm labor. Hence, a supply function for family labor for the United States also was estimated. With no previous quantitative analysis for family labor, the hypotheses adopted were the same as those for hired labor. Thus, the supply function for family labor was specified with the same variables as for hired labor, except that the nonfarm wage-rate variable was included for the present year and lagged one year. Estimates again were based on the Theil-Basmann technique, using autoregressive least-squares equations. To assist further in the determination of the dominant factors affecting the supply of family labor, an analysis was made of the variables affecting the net migration from farms.

The Supply Function for Family Labor in the United States

In the estimation of autoregressive least-squares equations, several iterations are "run" until negligible changes occur among the estimated coefficients. The results of the second iteration estimating the supply function for family labor indicated large and inconsistent changes from the previous iteration among the lagged variable, time, and the estimate of B — the autoregressive coefficient. However, the regression coefficients of the farm wage rate and nonfarm wage rate changed little. Evidently, without highly significant independent variables other than time and the lagged dependent variable, problems of multicollinearity arose. On the initial iteration, however, as the iteration was beginning to "settle down," the estimated family labor supply function for 1929-57 is:

$$(9.36) \qquad Q_{Ft} = .17P_{Ht} - \underset{(.74)}{1.08T} - \underset{(.05)}{.013P'_{Nt}} - \underset{(.07)}{.079P'_{Nt-1}} + \underset{(.36)}{.52Q_{Ft-1}} .$$

The variables in (9.36) are measured as deviations from the mean. The variables are Q_{Ft}, the supply quantity of farm labor; P_{Ht}, the index of farm wage rates deflated by the index of prices paid by farmers for production expenses; T, time; P'_{Nt}, the nonfarm composite wage variable explained in Chapter 8; and P'_{Nt-1}, the same variable lagged 1 year. The regression coefficients of equation (9.36) were "consistent" in sign, and had significance levels as follows: The variables for the composite nonfarm wage rate lagged one year, time, and the family

[11] See Fuguitt, Glenn V. Part-time farming and the push-pull hypothesis. American Journal of Sociology 44:375-79. 1959; Hagood, Margaret J., and Sharp, Emmit F. Rural-urban migration in Wisconsin, 1940-1950. Wis. Agr. Exp. Sta. Res. Bul. 176. 1951; and McDonald, Stephen L. Farm out-migration as an integrative adjustment of economic growth. Social Forces 34:119-28. 1955.

labor force lagged one year were significant at the 60 to 80 percent probability level, but the farm wage rate and nonfarm wage rate (for the present year) were significant only below the 60 percent level. The autoregression coefficient, B = .65, was not significant at the 80 percent level. Upon the completion of the next iteration, the coefficients of the remaining variables changed erratically. Consequently, because of the unfinished estimation of the supply function for family labor, elasticities were not derived. However, the size and significance of the primary explanatory variables are of interest. Nonsignificant results (i.e., not significant at the 60 percent probability level) were obtained both for the farm wage rate and for the nonfarm wage-rate variables. The results are similar to those obtained in the estimate of the supply function for hired labor.

The supply of family labor was also estimated for the same period, 1929-57, by ordinary least-squares methods. In these equations, coefficients for the nonfarm wage rate and the percentage of unemployment were estimated separately. The resulting supply functions are presented below, with the observations measured as deviations from the mean:

$$(9.37) \quad Q_{Ft} = \underset{(.101)}{.136P_{Ht}} - \underset{(.176)}{.408T} - \underset{(.096)}{.152P_{Nt}} + \underset{(.137)}{.139U_t} + \underset{(.145)}{.773Q_{Ft-1}}$$

$$(9.38) \quad Q_{Ft} = \underset{(.059)}{.132P_{Ht}} - \underset{(.153)}{.405T} - \underset{(.078)}{.149P_{Nt}} + \underset{(.103)}{.135U_t} + \underset{(.136)}{.774Q_{Ft-1}}$$

where U_t is percent of unemployment in the national economy, P_{Nt} is the nonfarm wage rate deflated by the index of prices paid by farmers for living expenses and other variables are as indicated for equation (9.36). Equation (9.37) was estimated from a system of equations, and equation (9.38) was estimated singly. The farm wage-rate coefficients of these equations were similar to those of (9.36). The significance levels were higher in equations (9.37) and (9.38), however, reaching the 95 percent level in equation (9.38). The nonfarm wage-rate coefficients were also significant at a higher probability level though not directly comparable. (Had the iterative procedure "settled down," all the coefficients of equation (9.36) may have been significant at the 80 percent level or greater.)

Based on the tentative results of equation (9.37), the supply of family labor appears to respond only slightly to the farm wage rate and the nonfarm wage rate. Again, we believe the availability of nonfarm employment to have dominated the farm labor supply function over the last several years of rapid mechanization of agriculture as suggested in the analysis of the previous section and the equations to follow.

Analysis of Net Farm Migration

Our hypothesis is that the migration from farms is mainly and directly in response to off-farm employment opportunities. The estimated supply functions presented above provide one test of this hypothesis, the results indicating a relative lack of response of the farm labor supply to both wage-rate variables. Hence, we now analyze farm labor from the standpoint of net changes in the farm population Q_L. An autoregressive transformation was not used in these estimates. The time period covered again was 1929-57. The resultant equation with the observations measured as deviations from the mean was:[12]

$$(9.39)\quad Q_{Lt} = \underset{(.184)}{.255P_{Ht}} - \underset{(.053)}{.099P_{Rt-1}} - \underset{(.210)}{.492T} - \underset{(.071)}{.069P'_{Nt-1}} - \underset{(.022)}{.023Q_{Lt-1}}.$$

The value of R^2 for equation (9.39) is .36. The sign of the farm wage-rate coefficient, taken alone, would indicate that as the wage rate has risen, there has been an accompanying net return of labor to farms. Similarly, the coefficient of the composite nonfarm wage rate and employment variable indicates that as this variable increased in the previous year, there was an accompanying net migration from farms. The signs of the regression coefficients were as expected for all but one of the variables. The sign of the parity ratio, P_R, was negative, indicating that as the parity ratio increased in the previous year, there was an accompanying net departure from the farm. The time periods in which the parity ratio increased were similarly periods when nonfarm employment opportunities increased most rapidly. The anomalous coefficient may be explained from the findings of the previous section. That is, coefficients indicating the influence of farm variables (e.g., income or parity ratio) on farm labor mobility only have meaning in relation to the rate of national unemployment. Failure to account adequately for the influence of national unemployment on labor mobility may result in wrong signs of coefficients.

SHORT-RUN PROJECTIONS OF FARM EMPLOYMENT

The short-run projections of family employment for 1965 in this section supplement the long-run projections of farm labor employment and requirements for 1980 made in Chapter 18. The short-run projections are based on the single least-squares equation (9.22) presented earlier. The structure postulated by the single linear equation is somewhat rigid for long-run projections. Hence, the projections to 1980 in Chapter 18 are based on a less formal "nonstructural" algebraic form.

Figure 9.6 illustrates that the number of family workers in

---

[12] The regression variables are as defined previously, except Q_{Lt-1} which is the annual net migration from farms, United States.

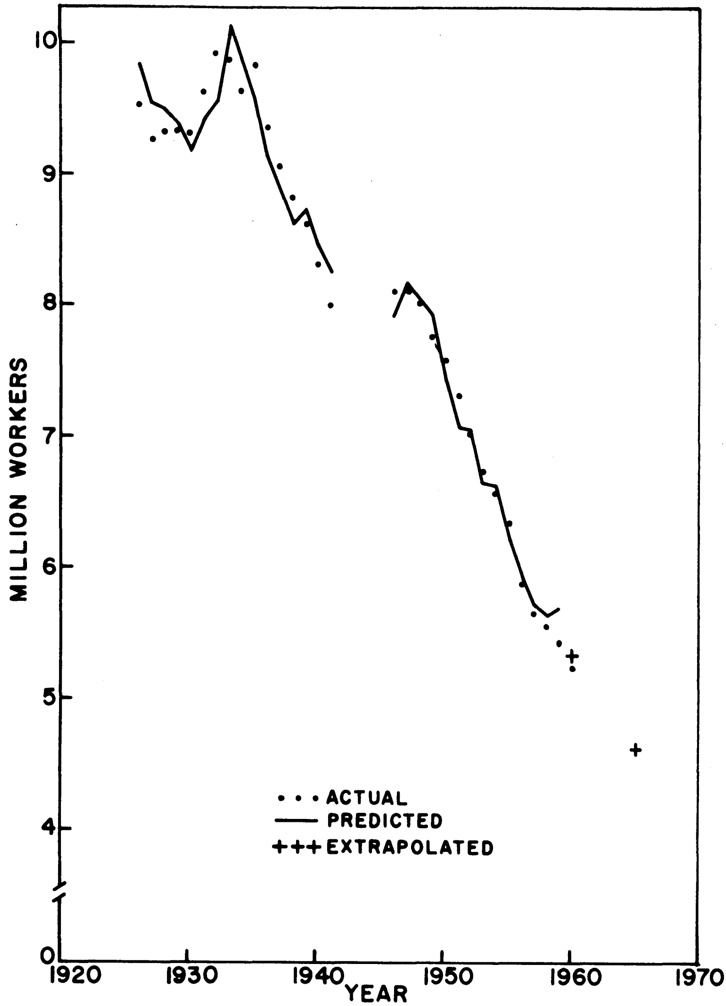

Figure 9.6. Trends in numbers of family workers in farming from 1926 to 1960 (predicted and projected estimates from equation 9.22).

agriculture dropped sharply from the mid-1930's to the present. The increase in labor numbers during the depression years of the 1930's indicates labor mobility is related to economic conditions, as do equations (9.18) through (9.36) of the text. The out-migration was interrupted by World War II but continued at nearly the same linear rate during the postwar years that was established in the late 1930's. There is some evidence that the rate is slowing. Out-migration remains large, however.

The actual values of the farm labor force are predicted by equation (9.22) in Figure 9.6. In general, the predictions are quite accurate.

The number of workers is estimated for 1960 by extrapolating from 1959 values of explanatory variables. The actual number of workers is overestimated slightly, but the error is small. The number of family workers is projected to 1965 from equation (9.22), assuming relative income and equity will remain at 1955-59 levels. The projected number of family workers for 1965 is slightly over 4.6 million. The number approximately is 14 percent below the predicted 1960 number. The results suggest that the number of workers in agriculture will be considerably less in 1965. Whether this reduction will increase per worker income in agriculture depends on movements in total net farm income.

IMPLICATIONS OF RESULTS

The several sets of family labor functions of this chapter have established links among returns to labor in agriculture relative to nonfarm wage rates and level of farm employment. The labor functions also provide an empirical link between labor employment in agriculture and the degree of unemployment in the nonfarm economy. Approximately a 20 percent rate of unemployment has reduced net farm migration to zero in past decades. Even in more recent times, national unemployment, though at a much smaller rate than in the 1930's, has greatly lessened the rate of net out-migration from agriculture.

Income per family worker did not improve relative to nonfarm income from 1926 to 1959 because the outmovement of farm workers was just rapid enough to compensate for the reduction in total residual income resulting from farm adoption of output increasing (income decreasing) farm technology. That is, the reduction in number of family workers was offset by the decrease in residual farm income, leaving relative income per worker unimproved. If institutional or other barriers to off-farm migration had been great, income per worker in agriculture would have decreased. Perhaps it is notable that farm technology and capital investment were sufficiently labor saving and off-farm opportunities sufficiently large to prevent an even greater deterioration of the relative income per farm worker.

After adjusting for differences in skills and nonmonetary returns, a reduction of approximately 25 percent in family labor numbers would bring comparable returns in farming and industry, other things being equal. A free market economy is one of several alternatives which might be proposed to bring the needed adjustment. The results of Table 9.4 suggest that the elasticity of family employment with respect to relative income is no greater than .35, even in the long run. The inelastic response indicates that a given percentage drop in farm income is associated with a smaller percentage drop in employment. The result is that a fall in farm income reduces rather than increases income per farm worker, even in the long run. If narrowing the differential between farm and nonfarm incomes is a goal of farm policy, active programs may be necessary to increase farm labor mobility. Structures and elasticities for the past period are not necessarily those desired for the future.

The mobility of farm people was large in the 1950's because of the cumulative effects of such forces as education, transportation and communication media generally. For the benefit of farm people, particularly youth, there is necessity of a growing number of nonfarm employment opportunities and for public services which increase still further the elasticities in response of farm labor to relative differences in labor returns in agriculture.and nonfarm wage rates. In general, farm people have been at both a geographic and educational disadvantage in migration opportunities. Education, employment and monetary assistance which can help overcome these disadvantages will increase the elasticity of response of farm labor. As Table 9.5 indicates, this aid will be needed. Not only are farm labor opportunities highly negative relative to the rest of the economy, but also the agricultural population has tended to average lowest in educational attainment.

Increasing numbers of farm persons will turn to nonfarm employment at a time when an excess occurs in the labor force because of the jump in the birth rates during the 1940's. The number of new entrants in the national labor force will average upwards of 2,600,000 per year during the 1960's, an increase of 40 percent over the 1950's. (The number of young persons reaching 18 years of age is predicted to increase from 2.6 million annually in 1960 to 3.8 million in 1965.) The number of new jobs created during the 1950's averaged about 2.3 million annually. Hence, without stepped up growth rate, competition for employment will be keen, disadvantage lying mostly with those having least preparation and knowledge of opportunities. Employment opportunity is predicted to increase in professional, technical, clerical,

Table 9.5. Projected Change 1960 to 1970 in Job Opportunities in Selected Employment Categories and Average Education of Persons Employed in Category in 1959*

Type of Worker	Change in Opportunities, 1960 to 1970	Average Schooling, 1959
	(percent)	(years)
Professional and technical	+42	16.2
Proprietors and managers	+23	12.4
Clerical and sales	+25	12.5
Skilled craftsmen	+23	11.0
Semiskilled operatives	+18	9.9
Service workers	+24	9.7
Unskilled laborers	0	8.6
Farmers and farm workers	-17	8.6

*U.S. Department of Labor. Manpower — challenge of the 1960's. Washington. 1960.

Table 9.6. Percentage Allocation of Vocational Education Funds Among Categories, Census Regions and Selected States, 1955-59*

Region or State	Percentage Allocation Within Region or State for:			Percentage Allocation of Region or State of U.S. for:		
	Agriculture	Home ec.	Trades and industry†	Agriculture	Home ec.	Trades and industry‡
U.S.	31	30	39	100	100	100
New England	11	18	71	2.3	3.8	12.8
Mid. Atlantic	16	13	71	6.5	5.6	24.4
E. North Central	31	31	38	16.3	17.2	16.3
W. North Central	41	31	28	12.3	9.8	5.9
S. Atlantic	36	34	30	19.9	20.0	12.8
E. South Central	42	36	22	11.2	10.1	4.7
W. South Central	42	38	20	20.9	20.1	7.0
Mountain	32	32	36	4.3	4.5	3.6
Pacific	21	28	51	6.4	8.9	12.4
New York	13	9	78	2.3	1.7	12.0
Minnesota	38	28	34	3.1	2.4	2.1
Iowa	49	33	18	2.7	1.9	.8
S. Carolina	44	36	20	2.8	2.4	.9
Georgia	44	40	16	4.8	4.6	1.2
Tennessee	37	38	25	2.8	3.0	1.6
Alabama	42	33	25	3.1	2.6	1.5
Mississippi	48	37	15	3.0	2.4	.7
California	19	26	55	3.8	5.7	9.1

*Digest of Annual Reports of State Boards for Vocational Education to the Office of Education, Division of Vocational Education. U.S. Dept. of Health, Education and Welfare. Office of Education. Fiscal years ending in 1955-59.

†Includes distributive occupations, nursing, area programs and other minor allocative categories.

‡Trades and industries only.

skilled, service and sales jobs, but to remain constant in unskilled jobs.[13] Hence, some unemployment is likely to prevail in unskilled jobs while shortages exist in professional and skilled positions favored by economic growth. Typically, a majority of migrants from farms first have had to seek or remain in unskilled employment, with approximately half the expansion in urban-industrial labor force between 1930 and 1955 coming through migration from the farm population.[14] Educational

[13] U.S. Department of Labor. Manpower - challenge of the 1960's. Washington. 1960.

[14] Ducoff, L. J. Trends and characteristics of farm populations in low income farming areas. Journal of Farm Economics 37:1399-1407. Over the single decade 1940-50, 8.6 million persons, alive in both 1940 and 1950, were added to the urban labor force through net migration from agriculture.

and vocational training deficiencies of rural areas (see Table 9.6) cause farm migrants to be at a disadvantage in migration and nonfarm employment. This is importantly true for farm youth, but particularly true for persons of 35 years and up who have spent their entire lives in farming and have had but little education oriented towards modern industrial employment requirements.

Increasing the mobility of farm workers through improved skills, subsidies or loans to migrants and through national employment agencies to disseminate job information is desirable from the standpoint of economic efficiency and societal welfare. It is even more desirable for farm persons who otherwise would be crowded "forever" into agriculture at low return. If the annual marginal value product (contribution to the real income of society) is much higher in nonfarm employment, the gains to society are large indeed from movement of 150,000 family workers per year from farm to urban employment. National income is increased a great deal by the migration of farm people to jobs paying $2000 per year more than their former employment. Even if this is only a crude indication of the real gains to the individual (salary) and to society (marginal value product), it does emphasize some of the actual and potential benefits of a more mobile population. There are few gains in increasing the mobility of the farm population, however, if national unemployment is high. In fact, the national income may be reduced by migration if unemployment is high. The marginal product of the unemployed in agriculture essentially is zero, but in urban areas is negative because of unemployment compensation and other social costs. It follows that policies to encourage full national employment and a vigorous economy have important ramifications for farm people as well as for nonfarm people.