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MANPOWER REQUIREMENTS AND DEMAND IN AGRICULTURE BY REGIONS AND NATIONALLY, WITH ESTIMATION OF VOCATIONAL TRAINING AND EDUCATIONAL NEEDS AND PRODUCTIVITY.

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DESCRIPTORS- *EDUCATIONAL NEEDS, *AGRICULTURAL EDUCATION, *AGRICULTURE, *EMPLOYMENT PROJECTIONS, *MATHEMATICAL MODELS, EMPLOYMENT PATTERNS, GEOGRAPHIC REGIONS, FARM OCCUPATIONS,

THE PURPOSE OF THIS STUDY IS TO ESTIMATE THE MANPOWER REQUIREMENTS FOR THE NATION FOR 144 REGIONS THE TYPES OF SKILLS AND WORK ABILITIES REQUIRED BY AGRICULTURE IN THE NEXT 15 YEARS, AND THE TYPES AND AMOUNTS OF EDUCATION NEEDED. THE QUANTITATIVE ANALYSIS IS BEING MADE BY METHODS APPROPRIATE TO THE PHASES OF THE STUDY--(1) INTERRELATIONS AMONG REGIONS, COMMODITIES, AND SECTORS, DETERMINED BY INPUT-OUTPUT MODEL APPLICATION, (2) SPECIFICATIONS FOR EACH REGION AND ITS PRODUCTS BY THE DEVELOPMENT AND APPLICATION OF A MATHEMATICAL PROGRAMING MODEL, (3) ESTIMATION OF MANPOWER REQUIREMENTS FOR DIFFERENT CLASSES OF WORKERS BY ESTIMATION OF TIME-SERIES REGRESSION EQUATIONS, (4) ESTIMATION OF MIGRATION FROM FARMS, (5) MEASURE OF MARGINAL PRODUCTIVITY OF VOCATIONAL AND TECHNICAL EDUCATION BY THE DERIVATION OF FUNCTIONS INCLUDING VARIABLES REPRESENTING TYPES AND AMOUNTS OF TRAINING, AND (6) CONVERSION OF ESTIMATES INTO MANPOWER NEEDS AND TRAINING REQUIREMENTS BY USE OF GENERAL QUANTITATIVE ANALYSIS. IMPORTANT PROGRESS HAS BEEN MADE ON FOUR PHASES OF THE STUDY AND ALLOWS SPECIFICATIONS OF THE FUTURE STRUCTURE OF AGRICULTURE AND LABOR DEMAND BY REGIONS. PRESENT PROJECTIONS SHOW AN EVENTUAL DOMINATION OF AGRICULTURE BY TWO- AND THREE-MAN FORMS, WITH A MANAGER AND ONE OR TWO PERMANENT HIRED PERSONNEL, WHO WILL REQUIRE DIFFERENT KINDS OF VOCATIONAL AGRICULTURE TRAINING. FOR THE PROJECTED LARGE-SCALE SPECIALIZED UNIT IN PARTICULAR SECTORS OF AGRICULTURE, THE REQUIRED LARGER FORCES OF MORE TYPICAL LABOR AND SUPERVISORY AND MANAGEMENT PERSONNEL MAY BE BEST TRAINED BY INTENSIVE SHORT COURSES. PRELIMINARY FINDINGS INDICATE THE POTENTIAL USEFULNESS OF THESE ANALYSIS METHODS FOR OTHER VOCATIONAL AND TECHNICAL EDUCATION NEEDS. FURTHER PROGRESS ON ESTIMATES AND PROJECTIONS FOR AGRICULTURE WILL BE CONTINGENT ON THE COLLECTION OF SUFFICIENT DATA. THIS REPORT APPEARS IN "APPENDIX OF FINAL RESEARCH REPORTS FOR PROJECT IN RESEARCH AND DEVELOPMENT IN VOCATIONAL AND TECHNICAL EDUCATION, NON-METROPOLITAN AREAS" (ED 001 069) WHICH SUPPLEMENTS VT 001 546. (JM)

MANPOWER REQUIREMENTS AND DEMAND IN AGRICULTURE BY REGIONS AND NATIONALLY, WITH ESTIMATION OF VOCATIONAL TRAINING AND EDUCATIONAL NEEDS AND PRODUCTIVITY

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I. INTRODUCTION

This project deals with estimation of labor and manpower requirements in agriculture and the related agribusiness sector for the nation and for as many as 144 regions of the country. It deals with estimation of the types of skills and work abilities that will be required by each. Finally, it deals with the types and amounts of education needed and the return on the corresponding investment for vocational and technical education in agriculture for the nation, for regional and commodity sectors, and for the associated agribusiness sectors. As it estimates the work force and skill requirements in agriculture, the study also must estimate the further migration of labor and population from agriculture and the manner in which vocational and technical education of the rural community can be adapted so that it appropriately serves both those who will stay on farms and those who will migrate. Changing technical and vocational training needs have been one of the most rapidly changing phenomena of the U.S. and will be even more rapid in the 15 years ahead. The skill and knowledge needs of agriculture will change greatly in kinds and amount as the number of farms is halved in the next one and a half decades and as the farming industry becomes much more specialized.

While the industry will use less of both family and hired workers, the upcoming specialized nature of farming will place most of the agricultural labor force in two categories: (a) managers who perform some work but will be most importantly engaged in the scientific managerial or decision processes in a highly technical and precise farming process and (b) skilled workers who will serve as hired help but will need technical abilities beyond the requirements of the typical farm operator-laborer in the previous generation. While there will be some seasonal and unskilled labor remaining in agriculture, this category will decline relatively in the next two decades. With the rapidly growing scientific orientation of farming, persons in local agribusiness operations which serve farming will need much greater and more sophisticated scientific and technical training. This need is reflected in the tendency whereby large chemical firms, through local representatives, are beginning to provide mathematically devised plans for farmers which incorporate all of the biological, physical and economic aspects of farm production and management. Such trends will require a high skill requirement, not only for the agribusiness personnel who must interpret the computer-divised plans for farmers, but also for the farmers who must put plans into operation.

This research project is pointed towards the changes in agriculture and its vocational and technical training requirements in the next one and a half decades. Hence, a large portion of the analysis relates to estimation of the structure of the agricultural work force and its skill requirements at future points in time. For parts of the analysis, however, it has been necessary to establish tendencies through estimation of regression equations based on time-series data and which allow projections into the future.

A. Objectives

1. To estimate manpower needs and labor demand in agriculture by 144 regions and nationally.
2. To relate manpower needs and skill requirements in agriculture to the structure and capitalization of farming and the scientific transformation of the industry.
3. To estimate manpower use and labor demand by categories including managers, temporary family labor, seasonal farm workers, permanent hired labor and other categories.
4. To relate the labor force of agriculture in terms of managers and workers to sizes, numbers, and structure of farms.
5. To estimate the off-farm labor force needed to serve agriculture regionally through the agribusiness sectors providing farm input services.
6. To determine the interrelationships of all of the above sectors in the use and skill training of labor relating to agriculture.
7. To outline the types, nature and operational methods of vocational training and technical education best adapted to serve the future structure of agriculture (including agribusiness sectors) in terms of farm managers, skilled farm workers and the various crops and livestock enterprises of the industry.
8. To estimate the marginal productivity of different amounts and types of vocational education and technical training so provided.
9. To outline an educational and training policy better suited to meet the needs and structure of future agriculture and agribusiness sectors.

II. METHODS

The quantitative analysis is being made by methods appropriate to six phases of the study.

(1) The application of input-output models to determine the interrelations among agricultural regions, agricultural commodities and the agribusiness sectors that serve agriculture through buying and selling activities. Once the matrix of these interdependency

coefficients has been established and projected, we can determine the effect on labor and on manpower and material requirements in the various regional, commodity and agribusiness sectors as change takes place in total demand and in the structure of a particular region or sector.

(2) The development and application of a mathematical programming model which allows specification for each of the 144 regions of agriculture and their major products and for the nation. This model, with the projection of technological change and the scientific transformation of agriculture, allows determination of the prospective structure of the nation's agriculture and the commodities, organization, degree of specialization, work force and skill requirements by each region. Although the estimates can be derived for each specific region, the model is built to allow expression of the simultaneous interdependence among regions -- an accomplishment possible only through this type of model. From these data, it is possible to generate the regional characteristics by degree of specialization, farm numbers and work-force requirements.

(3) The estimation, regionally and nationally, of the manpower requirements for different classes of workers and skills. This analysis requires estimation of time-series regression equations containing appropriate variables endogenous to the model, it is possible to indicate the total demand for labor of various classes and to indicate the number needed to enter the industry annually.

(4) The estimation, regionally and nationally, of the migration of labor from farms, with subsequent measurement or indication of the destination of these persons. These data are generated as a basis for indicating the major types of vocational and technical education needed in the rural community for the share of the farm labor force that leaves agriculture.

(5) The derivation of production functions that include variables representing different types and amounts of vocational training and education. The purpose of these estimates, insofar as they prove successful, is to measure the marginal productivity of vocational and technical training or education.

(6) More general quantitative analysis which uses coefficients from general sources to convert the other estimates into manpower needs for different commodities, regions and labor classes and to project the total requirements for vocational and technical education in each of these categories.

III. RESULTS

Progress and results are reported by methods and phases.

Each of the six categories of quantitative estimates explained above represents a fairly substantial empirical study. While data and time difficulties have occurred in some of the steps, progress has been made in all but one. In addition to these "heavy" quantitative analyses, the study also involves a policy or interpretative analysis to translate the empirical results into a specification of the amount, types and location of investment in vocational training and technical education for agriculture and for the agribusiness sectors of rural communities. The latter step involves, not only specification of the amount of facilities and investment needed by regions, but also a specification of curricula and course contents to conform with the developing structure of agriculture relative to the changing scientific and management characteristics of the industry and the stratification of labor into different groups than have prevailed in the past. Progress by the phases and methods is outlined below:

1. Intersectoral flows and dependencies for agriculture and labor.

This phase of the project is being analyzed through an input-output model of the conventional Leontief type. This model divides agriculture into regions and commodities to determine the flows and interdependence among them. It also relates each and all of these regional and commodity sectors to the nonfarm sectors which provide inputs or materials to agriculture and which acquire products for processing from the farm industry. This model is used to determine the effect of changes in national population and food demand on the input and labor requirements of agriculture on the various other sectors. These coefficients then are transformed into labor requirements in the agribusiness sectors. The initial goal was to complete this model for both 1960 and 1965 to allow projection of trends. Because data from the 1965 agricultural census did not become available soon enough in the year, however, only the model based on 1960 data could be completed. Upon extension of the project, the 1965 phase for the interrelationships among farm regions and products and the numerous agribusiness sectors will be completed. (Without extension of the project, interdependence coefficients based on 1960 alone will be used to measure the input and labor required as flows among sectors take place with various future final demand requirements on agriculture.)

The mathematical nature of the open model applied is outlined below. An open model refers to the condition that some sectors (i.e., farm regions, commodities and agribusiness sectors) are related to other sectors, but are not functionally dependent on them. Final demand (exports, government purchases, consumer purchases, etc.) is autonomously determined by factors outside the system. Labor and managerial services are then considered as inputs, but not as products functionally related to the household or family sector.

The open model is:

$$
(1)\quad
\begin{array}{l}
X_1 - X_{11} - X_{12} - \dots - X_{1n} = Y_1 \\
X_2 - X_{21} - X_{22} - \dots - X_{2n} = Y_2 \\
\vdots \\
X_n - X_{n1} - X_{n2} - \dots - X_{nn} = Y_n
\end{array}
$$

where X_1, X_2, ..., X_n represent gross output of the various economic sectors; X_{ij} (i, j=1, ..., n) represents actual flows of resource inputs and services from sector k to sector j; and Y_i (i=1, ..., n) are the flows to final demand sectors (household consumption, government, foreign trade). In this case, sector i (j) is a farm region, farm commodity or agribusiness activity.

The constraining assumptions made in input-output analysis are reflected in the relations between purchases or input demand of an endogenous sector (i.e., X_{ij}) and the level of output of this sector (i.e., X_j). Assuming a linear relationship the equation is:

(2) $X_{ij} = a_{ij}X_j + c_{ij}$

where a_{ij} and c_{ij} are parameters.

In the empirical work following, the assumption is made that $c_{ij} = 0$. The a_{ij} (the input-output, technological or requirements coefficient) is derived as the ratio between X_{ij} and X_j:

(3) $a_{ij} = X_{ij}X_j^{-1}$

The input-output coefficient represents the direct requirement of sector j upon sector i per unit of output of sector j. In this sense, it serves somewhat as a "technological reflection of demand" by sector j, per unit of its output. The X_{ij} similarly reflect the "total demand" of sector j for input from sector i in this same "technological manner." Thus, if output of an agricultural sector (j) requires $2 million of materials from the chemical sector (i), and if total output of the agricultural sector is $200 million, the related technical coefficient is 2/200 = .01. The agricultural sector has direct requirement or "demand" for .01 dollar of inputs drawn from the chemical sector for each dollar of farm sector output, the total chemical "input demand" being $2 million.

Substituting (2) into (3) yields:

$$
\begin{array}{ll}
 & X_1 - a_{11}X_1 - a_{12}X_2 - \dots - a_{1n}X_n = Y_1 \\
 & X_2 - a_{12}X_1 - a_{22}X_2 - \dots - a_{2n}X_n = Y_2 \\
(4) & \cdot \qquad\qquad\qquad\qquad\qquad\qquad \cdot \\
 & \cdot \qquad\qquad\qquad\qquad\qquad\qquad \cdot \\
 & \cdot \qquad\qquad\qquad\qquad\qquad\qquad \cdot \\
 & X_n - a_{n1}X_1 - a_{n2}X_2 - \dots - a_{nn}X_n = Y_n
\end{array}
$$

or in matrix notation:

(5) $X - AX = Y$

where X is the vector of sector outputs, A is the matrix of input-output coefficients and Y is the vector of final demand quantities. Hence, with specified final demands, Y_1, Y_2, ..., Y_n and constant input-output or resource requirement coefficients, equation (4) can be solved for the outputs X_1, X_2, ... X_n; the resulting equations are given in (6). The A_{ij}'s are elements of the inverse matrix $(I - A)^1$

$$X_1 = A_{11}Y_1 + A_{12}Y_2 + \ldots + A_{1n}Y_n$$

$$X_2 = A_{21}Y_1 + A_{22}Y_2 + \ldots + A_{2n}Y_n$$

$$(6) \quad \begin{array}{ccc} \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \end{array}$$

$$X_n = A_{n1}Y_1 + A_{n2}Y_2 + \ldots + A_{nn}Y_n$$

or, in matrix notation:

$$(7) \quad X = (I - A)^{-1}Y$$

Equations (1) and (4) represent the descriptive component, and equation (6) represents the analytical aspect of an input-output model. However, from the standpoint of labor and resource "demand" and intersector structure of agriculture, the elements of matrix A are of as much interest as those of $(I - A)^{-1}$. By using the definitional equation to simplify later presentation,

$$(8) \quad (I - A)^{-1} = B$$

we have interest in A, to indicate all direct demand of sector j for demands on other sectors, and in B to indicate the sum total of direct and indirect demand upon a particular sector for a one-unit change delivered to final (consumer or exogenous) demand by a particular sector.

This model was applied to 90 sectors (regions and products) of agriculture and to 15 agribusiness sectors. The resulting coefficient matrix was 90 x 90 order. If the project is continued, the calculations will be extended to 1965 data, and the agribusiness sector will be divided into many more components. In either case, the step now being carried forward (the translation of the intersector interdependence coefficients into labor requirements) will be continued and projected into the future. The "gross model" for 1960 is completed. Extension of the analysis to 1965 and to more agribusiness sectors can greatly extend the detail of this part of the study, but also will require considerably more time and resources.

2. Programming projections of United States agricultural structure to the future, with indication of the production pattern, farm sizes and numbers, degree of specialization and work force by regions.

This analysis is being applied to the standard 144 agricultural regions of the study. It considers the 144 regions simultaneously since the degree of agricultural specialization and structural change of one region will depend on the relative advantage and role of other regions in meeting national food demands. This large-scale analysis is being applied for 1975 and 1980 and shows (a) regions which should shift to a different set of crop products and enterprises in the future, (b) the regions which will become more intensive and those which will be more extensive and decline most in manpower use, (c) the number and sizes of farms and the capital inputs and the labor force by regions and (d) other items relating to manpower and skill needs of farming per se.

The programming model developed for this step in the analysis involved 800 equations and 2,200 variables. Three solutions have been obtained with all major crops incorporated into the model. Basic and original intentions were to go as far as possible with these models during the 18 months for which the project was initially funded. A large empirical task was involved in accumulating and readying the data for the computations and in trial runs on the computer. Because of the mammoth amount of data to be assembled, ordered and processed, the project could be extended only through crops during the 18 months. Addition of livestock and realistic labor requirements and restraints requires that the model be extended to approximately 4,000 equations and 35,000 variables. However, inclusion of livestock can be accomplished if the project is extended.

The basic model specified which crop products will be produced in each of the 144 regions for future years and allows specification of the total labor requirements by these individual regions. The model indicates that some large regions, such as southeastern Wyoming, southern Colorado, parts of Missouri and many areas of the Southeast will shift from crops to forages and livestock, thus requiring different amounts of and skills for farm labor.

The actual model completed through the stage of machine computations during the year can be summarized as follows, where notation is provided only for each single region:

The basic manpower requirements, L_i, for the ith region (an individual one of the 144 regions) is determined as follows:

$$(8) \quad L_i = \sum_{e=1}^{t} \sum_{k=1}^{n} \alpha_{dgjk} \, \beta_{gjk} \, X_{ejk}$$

where α_{dgjk} is the amount of each type of standardized labor used for the gth farm operation on the kth product in the jth farm region, β_{gjk} is the amount of the gth farm operation used on the kth crop, and X_{ejk} is the amount of the kth product produced by the eth technology in the jth farm region. Summation is over crops and types of technology in the region.

The labor outcome for any one region can be determined only by total national demands, the labor and farm technology in all other regions for meeting these demands and the comparative advantage of the particular region. Hence, the model must include equations which express the restraints to production in each region, the labor-capital methods used and the general technology in the regions.

Total production in the ith region is restrained by the total cropland equation (9).

$$(9) \quad b_{10} \geq \sum_{k=1}^{4} a_{ijk}X_{jk} \qquad (i = j = 1,2, \ldots, 144),$$

and by the intraregional upper bounds on acreage for each crop in equation (10).

$$(10) \quad b_{ik} \geq a_{ijk}X_{jk} \qquad (i = j = 1,2, \ldots, 144;\ k = 1,2,3,4)$$

Minimum requirements for wheat, feed grains, and oilmeals in each consuming region are reflected in equations (11), (12) and (13), respectively.

$$(11) \quad d_{m1} \leq \sum_{j=1}^{n} X_{j1}P_{j1} + \sum_{r=1}^{31} T_{mr1} - R_s \qquad (m,r=1,2,\ldots,31;\ r\neq m);$$

$$(12) \quad d_{m2} \leq \sum_{j=1}^{n} X_{j2}P_{j2} + \sum_{r=1}^{31} T_{mr2} + R_s \qquad (m,r=1,2,\ldots,31;\ r\neq m);$$

$$(13) \quad d_{m3} \leq \sum_{j=1}^{n} X_{j3}P_{j3} + \sum_{r=1}^{31} T_{mr3} \qquad (m,r=1,2,\ldots,31;\ r\neq m).$$

The single national demand for cotton lint is specified as:

$$(14) \quad d_c \leq \sum_{j=1}^{144} X_{j4}P_{j4},$$

The symbols used in equations (9) through (14) are defined:

a_{ijk} = The amount of land used by one unit of the kth producing activity of the i = jth producing region; k = 1 for wheat, 2 for feed grains, 3 for soybeans, and 4 for cotton.

b_{ik} = The amount of land available for use by the kth crop in the ith producing region.

b_{10} = The total cropland available for production in the ith producing region.

c_{jk} = The cost of producing one unit of the kth crop in the jth producing region.

c_{mrp} = The cost of transporting one unit of the pth crop to (from) the mth demand region from (to) the rth demand region; r=30 is the maximum number of such activities that may occur for any crop since there are 31 demand regions.

c_3 = The cost of using one unit of wheat as a feed grain in the sth demand region (s=m). The cost is an artificial price differential in addition to the normal production costs.

d_c = The national demand for cotton lint expressed in pounds.

d_{mp} = The demand for the pth commodity, expressed in feed units, in the mth demand region; p = 1 for wheat, 2 for feed grains, and 3 for oilmeals.

P_{jk} = The per-unit output of the kth activity in the jth producing region, expressed in feed units for all except cotton lint, which is expressed in pounds.

$P_{j4'}$ = The oilmeal output, in feed units, of the cotton activity in the jth producing region.

R_s = The level of the activity transferring wheat into a feed grain in the sth demand region (m=s).

T_{mrp} = The level of transportation of the pth commodity to (from) the mth consuming region from (to) the rth consuming region.

X_{jk} = The level of the kth producing activity in the jth producing region.

The results of this model indicate some major regional changes for agriculture and its manpower requirements in the next

10 and 15 years. While the greatest number of the 144 regions will intensify their production, they also will become more specialized with a different emphasis in technology. However, a large number of regions in the fringe areas of the Great Plains and Corn Belt and over wide reaches of the Southeast are indicated to shift from present crop concentration to forage and livestock or forest farming. The labor requirements and manpower needs are computed accordingly. The basic means for establishing the number of farms and farm operators has been established and is ready for application. It should indicate the training requirements for farm managers by regions.

While detailed data are available for the 144 individual regions, a few national summary items are provided here on the predicted structure of agriculture. The national data show a projected shift of 75 million acres among field crops, and from field crops to grass and trees to 1980. The projected number of farms is slightly more than 2 million, with a work force of 3.5 million. In relation to the agribusiness sector, inflows of fertilizer and lime will increase nationally by 97 percent, livestock and feed by 36 percent, operating inputs represented by chemicals and related items will increase by 49 percent. Much greater details are available by regions and input or resource categories.

3. Estimation of demand equations for different classes of farm labor.

While the several facets already outlined have been completed or conducted, regionally and nationally, to determine the structure of agriculture and its related labor and training needs, the greatest part of the empirical work has emphasized the derivation, regionally and nationally, of labor demand and manpower requirements equations. The approaches used and some sample results are explained below.

Work on this phase of the project has been along two lines: the establishment of manpower requirements for agriculture for several future dates and the establishment of the training and educational requirements for this manpower. Work on both phases has been concurrent, although greatest emphasis has been on the manpower estimates to date. This emphasis is necessary so that manpower estimates are available for making specific recommendations about training and educational requirements. For manpower requirements and labor demand, a large number of regression models have been completed by the major regions and for the nation as a whole. The resulting equations have been reviewed, analyzed, modified and, where necessary, recomputed. A total of 4,000 equations were considered in this phase of the project. Resulting has been a set of equations meeting the desired standards established for the statistical analysis. Of the 4,000 equations, 140 equations have been selected each for hired labor, family labor and total farm operator labor.

After estimation of the labor demand and migration equations, it was necessary to project exogenous variables into the future so that manpower requirements could be estimated at the appropriate future dates. Hence, analysis for these exogenous variables was necessary. The first of these analyses was graphic and involved 144 graphs of the variables involved. The second analysis used regression and tested for linear, quadratic log and inverse trends in the exogenous variables. A total of 420 equations were computed.

For developing manpower demand, the equations were subjected to three criteria: (a) the highest possible R^2, (b) all regression coefficients significant at the .05 level or better, (c) no equation should predict a zero or negative net demand for labor. The first two of these requirements were used to meet statistical reliability; the third, to avoid nonsensical results. Labor-demand equations were established regionally and nationally for estimating all classes of farm labor — farm population, hired labor, family labor and total labor. These estimates were made with models having 17 independent variables, representing several measures of both farm and nonfarm factors influencing farm labor requirements.

Several possible forms for the demand equations were established for each of the four labor groups. Data for each of the 17 independent variables were collected for 1938-64 in the national regressions and for 1940-64 in the regional regressions.

After some initial testing of the hypothesis that manpower projections could be made by using regression types of demand equations, the following plan evolved. First, a set of demand independent variables were selected for projecting exogenous variables to specified times into the future. These values of the exogenous variables then were entered in the estimated labor demand equations where they were relevant. These estimates have been completed, and the results indicate the predicted levels of farm population, hired farm labor, family farm labor and total farm labor in each of the regions and the nation at times in the future. For projections relative to the exogenous variables or measures, there are three estimates and an average for each measure in the national estimates. Evaluation and reconciliation of these estimates is just being completed. When anomalies (e.g., hired + family $\neq$ to total labor), are observed, reasons are being sought, and (if necessary) revisions will be made.

Using this information, predictions of the 1970, 1975 and 1980 values of all 17 variables of the labor demand equations in each of the regions and nationally were made. This step was essentially a computing job, and a computer program was written to produce, in an orderly fashion, the 1,260 values of the independent variables and their 1,260 logarithmic values.

As an example of the demand functions estimated both nationally and by regions, aggregative results are presented below for three of the classes of farm labor and farm population.

The Farm Population ($R^2 = .993$)

$$Y_4 = 7.3379 - \underset{(.0208)}{.0634}X_2 - \underset{(.0566)}{.2557}X_5 - \underset{(.2029)}{.6767}X_{15} - \underset{(.2759)}{.2599}X_{19}$$

Hired Farm Labor ($R^2 = .998$)

$$Y_5 = 5.1517 - \underset{(.0221)}{.1661}X_{1(t-1)} - \underset{(.0418)}{.2250}X_4 - \underset{(.0636)}{.1411}X_{15}$$

Family Workers ($R^2 = .989$)

$$Y_6 = 5.6391 + \underset{(.0249)}{.1710}X_{1(t-1)} - \underset{(.0506)}{.3587}X_5 - \underset{(.0205)}{.4319}X_{19}$$

Total Farm Labor ($R^2 = .990$)

$$Y_7 = 5.6646 + \underset{(.0221)}{.0780}X_{1(t-1)} - \underset{(.0449)}{.3221}X_5 - \underset{(.0182)}{.3565}X_{19}$$

where:

Y_4 = Farm population (1,000)
Y_5 = hired farm labor (1,000)
Y_6 = family workers (1,000)
Y_7 = total farm workers (1,000)
X_1 = farm wage rate (deflated index)
X_2 = net farm income (million dollars deflated)
X_4 = nonfarm income (million dollars deflated)
X_5 = nonfarm per capita income (dollars deflated)
X_{14} = the index of mechanical power (1957-59 = 100)
X_{15} = cropland per farm (index, 1957-59 = 100)
X_{19} = farm labor productivity (index, 1957-59 = 100)

All variables are measured in logarithms to the base 10, and the time-series observations are for 1940-64 inclusive. Similar results have been obtained for each of the individual regions.

Projections for a Corn Belt region in 1980 are presented below where units are 1000.

	1964	1980	Percent Change
The Farm Population	2,549	1,797	-30
Hired Farm Labor	156	131	-16
Family Workers	963	633	-34
All Workers	1,119	761	-20

This example parallels that for other regions wherein hired farm workers decline by less than family workers. Under the projected structure of agriculture developed in other phases of the study, we expect more year-around and skilled hired labor.

Throughout this study, extensive use has been made of Iowa State University's IBM 360-50 computer. A total of 15 programs have been written for this machine, to handle the particular problems of the project. Programs were written by personnel employed on the project and have provided for data generation, regression transformations, inverse transformations, independent variable projections, equation solutions and dependent variable predictions.

The demand for labor can be determined only in terms of the important variables that relate to its usage, quality and migration. The interrelationships among these variables are extremely complex and can be determined only after length analyses and comparisons of different time-series regression models. Variables used in this study include: trends in technology, farm labor productivity, farm income, farm machinery prices, farm wage rates, farm educational levels, the level of mechanization, the mix of farm products produced, per capita incomes of nonfarm employees, the population and age distribution of farm persons, the size of farms, the index of cropland per farm, the index of prices of land and farm buildings, the lagged unemployment rate, the levels of national income and total nonfarm employment, and others relating to both the number of persons and man-hour requirements. Various types of regression models were employed in these estimates. Both single and simultaneous equation models were explored in the analysis. Most of the estimates are based on single equation models, with various lags in independent variables.

The many results for the regions and nation cannot be presented here because of space limitations. Likewise, it is not feasible to present the demand equations and manpower projections for the future in each region and for each class of labor. As an extreme summary of types of predictions and interpretations available, simple national elasticities derived from the demand equations are presented for only two classes of labor: family labor and hired labor as two "gross categories." A summary of these elasticities is presented in the table.

IV. DISCUSSION

The translation of labor demand and manpower requirements into amounts and kinds of vocational education and technical training cannot be completed until final synthesis is made of the several sets of quantitative data discussed. Similarly, specification of organization and policy for this education in the rural community, directed towards both the farm and agribusiness sectors, cannot be completed until the synthesis of quantitative results has progressed. However, several alternatives to the present structure of vocational and technical training have been examined.

The quantitative results pose several hypotheses for the future structuring of vocational educational training for agriculture. The results of one model, the programming results explaining the interregional shifts and specialization of agriculture, can be used as an example. This model indicates some major shifts among regions, some shifting from crops to more extensive production with still fewer farms and a smaller labor force. Other regions would concentrate on a more intensive but highly scientific and specialized agriculture.

In a preliminary analysis, used as a guide and model to be followed in determining the amount and quantity of labor and hence, training required in those regions shifting their agriculture to a less intensive basis, it was found that vocational training units to provide the range and depth of skills required, would entail fewer vocational training departments devoted solely to farming. However, these shifts in farming and training structure also would require, in each of these units or departments, more than one specialist so that the expected and necessary subject matter can be covered. In addition, a smaller number of high schools covering a wider territory could be used for an advanced third year directed towards the managerial-oriented segment of the farm labor force.

In contrast to these regions expected to shift from more intensive to extensive farming, other regions are projected to maintain the same product mix but to increase the volume.

Demand elasticities for hired and family farm employees with respect to explanatory variables used in demand equations for hired and family farm employees.

Explanatory variable	Demand for hired farm employees	Demand for family farm employees
Price of agricultural resources		
Index of farm wage rate, X_1	-.149 to 0.404	.182 to .373
Index of the price of land and buildings, X_{10}	-.380 to -.545	-.325 to -.627
Index of the ratio of the farm wage rate to the price of land and buildings, X_{23}	-.071 to -.667	.196
Index of the ratio of the farm wage rate to the price of farm machinery, X_{24}	-.129	.248
Returns in agriculture		
Net farm income, X_2	-.095 to -.147	.071 to .184
Net income per farm, X_3	-.102 to -.138	.098 to .197
Nonagricultural returns		
Per capital income of nonagricultural employees, X_5	-.118 to -.337	.348 to -.636
Nonfarm economic activity		
Nonfarm income, X_4	-.147 to -.325	-.300 to -.558
Lagged number of employees on nonagricultural payrolls, $X_{6(t-1)}$	-.459	.255 to -.414
Lagged unemployment rate, $X_{7(t-1)}$	.035 to .083	.038 to .044
Mechanization		
Lagged index of stock of mechanical power and machinery, $X_{14(t-1)}$	-.115	-.066 to -.186
Technology		
Index of cropland per farm, X_{15}	-.141 to -.625	.862
Index of farm production per man-hour, X_{19}	-.117 to -.274	-.115 to -.432
Time, X_{22}	-.354 to -.822	-.760 to -1.54

However, the skill requirements in farming are stepped up to require more scientific knowledge, and attempt is being made to synthesize the knowledge requirements for managerial, vocational and technical training. Finally, a new model of training, related to the concept of the input-output matrix or resource flows, is being developed to provide estimates for the knowledge and skill requirements for the regional or local agribusiness sectors to serve agriculture.

V. CONCLUSIONS

We now summarize differences between the elasticities for family and hired labor as indicated in the table. This summary is only suggestive of the many detailed data available regionally and nationally from the study. (The variables specified are those included in the table.)

Comparing hired and family farm-labor demand with respect to the farm wage rate, the negative relationship on hired-labor demand and the positive effect on family labor is notable. Evidently, the demand for hired farm labor is a demand for labor as a competitive resource. The farm wage rate may be representative of returns in agriculture for family farm labor, hence the positive sign. It could be hypothesized that family and hired farm labor are close substitutes. When farm wage rates increase, family labor assumes a relatively stronger position in agriculture since hired labor is "priced out" as a resource.

When the price of land and buildings, X_{10}, is used as an explanatory variable, negative coefficients of similar elasticities are observed for hired and family labor. The absence of a land-labor substitution effect is implied by this negative effect of X_{10} on the demand for hired and family labor.

By using ratios of resource prices, a substitution effect of land and machinery for hired farm labor is observed. However, this is not the case with respect to family farm labor. The reason likely is that the farm wage rate represents a "price" for the hired-labor resource, but not directly for family labor.

Sign differences exist for demand elasticities between family and hired farm labor with respect to net farm income and net income per farm. Hired farm labor is negatively related to farm income, while family farm labor is positively related. The positive association of family farm labor is truly a decision variable for family labor in deciding whether to enter, remain in, or leave agriculture. The negative relationship of hired farm employees to farm income is not as obvious. The negative effect may lie in a complex substitution relationship between hired and family farm labor. With gains in farm income, accompanied by larger farms and greater mechanization, hired farm employment declines as family labor assumes a relatively stronger position in agriculture.

The per capita income of nonagricultural employees, X_5, exerts a negative influence on both hired farm labor and family farm labor. It can be observed from the table that the range of demand elasticities for family farm labor with respect to this variable is higher than the comparable range for hired farm employees. It could be inferred from these ranges that family farm labor is more responsive to changes to nonfarm income than is hired farm labor. It has long been hypothesized that hired farm labor lacks education and training. With these "supply" characteristics tending to hold hired farm labor in agriculture, hired farm labor appears as a more stable element of farm labor, in response to nonfarm earning opportunities, than family farm labor.

The demand elasticities of hired and family farm labor with respect to nonfarm activity (X_4) and lagged nonfarm employees ($X_{6(t-1)}$) indicates little differential effect between hired and family farm employment. However, in comparing the effect of the lagged unemployment rates ($X_{7(t-1)}$) on family and hired farm employment a differential tendency seems to exist. The range of demand elasticities is higher for hired farm employment than for family farm employment. Assuming this difference to exist, hired farm employees appear more vulnerable to nonfarm job opportunities than do family farm laborers. While family farm labor may be more responsive to a decline to nonfarm earning opportunities than are hired farm employees, this may result from the lack of training and job opportunities for hired farm laborers. When job opportunities do grow, as demonstrated by a low unemployment rate, hired farm laborers then appear responsive in movement from agriculture at a relatively fast pace. This outmovement would more readily be possible if hired workers were provided appropriate vocational training.

As has already been discussed, the mechanization variable ($X_{14(t-1)}$) shows little differential effect between hired and family farm employment. The effect of technology and trend variables appears to be larger on family farm labor than on hired farm labor.

The entire set of exogenous variables has, as explained earlier, been projected to future dates as the basis for estimating farm labor by regions and categories. These quantities are more important to the study than are the elasticities just summarized, but do not lend themselves to simple interpretation in limited space.

While the entire set of equations, nationally, regionally and by category of farm labor, has been estimated and while 140 have been selected for prediction and projection, a complete interpretation of the results has not yet been made. Additional time is required to complete this step and to translate it into manpower requirements by regions, with corresponding training and skill requirements by labor categories.

VI. SUMMARY

Six methods are being used in this study and include input-output models, programming models, time series demand functions, labor migration functions, production functions for educational inputs and more general quantitative analyses to indicate the amounts, types and skills of farm labor needed by products and regions for the future. Important progress has been made on four phases of the study and allows specification of the future structure of agriculture and labor demand by regions. The estimates allow specification of labor by classes such as managers, skilled hired workers, family personnel, etc. They also will allow indication of labor inputs represented through intersectoral flows of inputs through the agribusiness sectors related to farming. The variables of prices, technology, mechanization and others allowing prediction of future labor use by classes of labor have been completely regionally. The structure of agriculture for the 144 regions also has been estimated, as a basis for the upcoming step in establishing vocational education and technical training requirements for the different classes of labor.

Specification of the optimum amounts, forms and facilities of vocational education and technical training can be done only if we know or can project certain information. This includes the number of farms, the degree of specialization in the industry and the extent to which farming is organized around large-scale units with one manager and several skilled laborers, the capital/labor ratio of the industry and the number of workers in each labor category, the scientific and management orientation of the industry, and related phenomena. A basic analysis of training needs for the future, with respect to labor and its skills and types of regions, products and tasks in farming, requires prediction and projection of the structure of agriculture itself.

A prediction of the structure is required because it is expressed in various types of the capital items that farming uses. On the one hand, these capital items substitute for labor, thus helping to determine how many laborers there will be. Also, the capital items determine the size and number of farms that will exist. This information is needed to determine how many farms there will be, and how specialized and how large they will become in terms of managerial resources and work force. For example, we are projecting the number of two and three-man farms for the future. This will help to determine (a) the proportion of the farm work force for whom the main educational and vocational training needs are to emphasize managerial abilities, (b) the proportion who will operate the machines, equipment and enterprises and thus need skills training rather than managerial training, and (c) the proportion who will serve purely as laborers and need a different background.

Our projections show an eventual domination of American agriculture by two and three-man farms. On these, the second and third man will eventually be permanent hired personnel, but with skill requirement entirely different from the conventional farm laborer of the past. They will use employment in year-around hired work as a professional activity and will be outside the migratory and seasonal category. They will have responsibility for machine and equipment operation and for enterprise implementation once the manager has decided the program. Hence, they may well be the ones for whom the technical or vocational training in agriculture of the past best applies, but with a need for changing the orientation of this education. The farm operator and manager, on the other hand, will require a different mix of knowledge for management operations. Finally, the projected large-scale specialized unit in particular sectors of agriculture will use larger forces of the more typical labor, as well as supervisory and management personnel, which may be best trained by intensive short-courses, rather than by year-long technical training in the high school curriculum.

Work in the following period can take the following forms. The research being completed for the farm and agribusiness sectors can become a model for analysis of vocational education and technical training needs in other sectors of the economy. It is, however, necessary to develop an extremely large amount of background data and estimates if the predictions and formulations are to have greatest applied value in specifying actual training needs by locations, suboccupations and phases of an industry. The greatest accomplishments in synthesizing the basic estimates of amounts of labor in different classes, and in using these as the basis for creating models in training and educational policy, must thus follow in the next period of the study. Following the large accomplishments reported for the initial phase of the study, the greatest payoff in completion and application of the data should come in the next 18 months of the project.

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15. ABSTRACT *(250 words max.)* This project deals with estimation of labor and manpower requirements in agriculture and the related agribusiness sector for the nation by 144 regions. It deals with estimation of types of skills and work abilities that will be required. Finally, it deals with types and amounts of education needed and the return on the corresponding investment for vocational and technical education in agriculture.

This research project is pointed towards changes in agriculture and its vocational and technical training requirements in the next one and a half decades.

The quantitative analysis has been divided into six major phases: (1) the application of input-output models to determine the interrelations among agricultural regions, agricultural commodities and the agribusiness sectors that serve agriculture through buying and selling activities; (2) the development and application of a mathematical programming model which allows specification for each of the 144 regions of agriculture and their major products and for the nation; (3) the estimation, regionally and nationally, of the manpower requirements for different classes of workers and skills; (4) the estimation, regionally and nationally, of the migration of labor from farms, with subsequent measurement or indication of the destination of these persons; (5) the derivation of production functions that include variables representing different types and amounts of vocational training and education, and (6) more general quantitative analysis which uses coefficients from general sources to convert the other estimates into manpower needs for different commodities, regions and labor classes and to project the total requirements for vocational and technical education in each of these categories.

This research can become a model to analyze other vocational & technical training needs.

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