An Input-Output Analysis
Emphasizing Regional and Commodity Sectors of Agriculture

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SUMMARY

This study includes an input-output analysis emphasizing regional and commodity sectors of American agriculture. The analysis is based on a 103-order input-output matrix of which a 90-order submatrix represents agriculture. The model used is applied to 1954 data in an attempt to provide certain descriptive relationships among sectors within agriculture and between agricultural and industrial sectors of the national economy.

Agriculture is divided into 10 type-of-farming regions. Nine product groups are identified in each region. Industry is aggregated nationally into (1) seven agricultural processing industries, (2) five agricultural furnishing industries and (3) one sector to represent "all other industries." Transactions are estimated between all producing and consuming sectors. These transactions are summarized in table A. Methodology for constructing them is given in Appendix A.

In terms of the empirical analysis, 88 percent of the demand for agricultural products is from interindustry sources. Twelve percent of the derived demand for agricultural output is from the final "bill of goods," i.e., home consumption, government, inventories and foreign trade. Within agriculture, feed crop sectors derive most of their demand from livestock sectors. On the other hand, large quantities of cotton and tobacco flow to final demand sectors. In contrast, industry derives 54 percent of its demand from final demand sectors. Agriculture purchases 3 percent of the gross production of industry, while industry purchases 61 percent of the gross output of agriculture. Regional differences also exist in respect to agriculture-industry sales patterns.

Input-output coefficients showing the unit cost structure of each sector are computed from the transaction table and are shown in table B. Each \( a_{ij} \) (input-output coefficient) shows the change in gross output required from sector \( i \) per dollar of sector \( j \) output. A dollar of agricultural output requires 32 cents of industrial inputs. In contrast \( f \) of industrial output requires only 5 cents of agricultural inputs. However, \( f \) of agricultural processing industry output requires 36 cents of agricultural inputs—approximately the farmer's share of the consumer food dollar.

The Northeast region shows the greatest direct dependence upon industry with purchases of 42 cents from industry, per dollar of agricultural output. Industrial requirements in the Northeast are relatively high because (1) this agricultural area is a "deficit" feed producer, requiring large quantities of purchased grains and formula feeds and (2) farms are small with large machinery investments per acre. In contrast, Mountain States require the least purchased inputs per dollar of output. This result parallels the production techniques used in this farming region, where the primary source of inputs for range cattle and sheep is native grasses produced within the agriculture of the area.

Interdependence coefficients, relating the final demand of a single sector to gross output of all other sectors, are based on data in the transaction table but are computed more directly from the input-output coefficient matrix. Each \( A_{ij} \) (interdependence coefficient) shows the change in gross output required from sector \( i \) per dollar of sector \( j \) output delivered to final demand.

A $1 delivery of agricultural goods (unprocessed) to final demand requires an increase of gross output in industry of 73 cents. In contrast, delivery of $1 of industry goods to final demand requires only a 12-cent increase in agricultural output. These data indicate the high dependence of agricultural sectors upon industry, while industry in general (other than processing sectors) shows minor dependence upon agriculture.

A one-dollar change in demand for agricultural processing goods (agricultural commodities which are processed by industry) has a diverse effect upon gross output in agricultural regions. It has the greatest effect in the Corn Belt. This region has an output of 15 cents associated with each $1 of agricultural processing goods moving to final demand. This amount is more than twice that for any other region. A dollar increase in demand for processed livestock and poultry products has an even greater requirement for crop output in the Corn Belt than it has for livestock output in the Northeast.

Each $1 of output delivered to final (consumer) demand by agricultural processing industries is associated with 59.1 cents of output from agriculture. Twenty-five percent of the 59.1 cents is generated in the Corn Belt; the corresponding figures are 6.7, 6.3, 6.0 and 62.2 cents respectively for these regions: the Lake States, and the Northeast, Northern Plains and Pacific states.

The Northern Plains is the farming region with greatest empirical dependence on other regional agricultural sectors. Delivery of $1 of products to final demand by this region is associated with 9.5 cents of output from other agricultural regions. Of this 9.5 cents, the Mountain States contribute 62 percent. Dependence of the Southern Plains in livestock also is important; the region uses, for each $1 of livestock going to final demand, 2.7 cents of feed grains from the Northern Plains and 6.9 cents of livestock and 2.0 cents of hay from the Mountain States. Each $1 of final demand contributed by Appalachian region livestock is associated with 3.9 cents of feed grain output in the Corn Belt. A similar quantity of livestock in the Delta States is associated with 11.4 cents of feed grain output from the Corn Belt.

Each $1 of final demand for processed food grains is associated with an output of 57 cents from agriculture and 38 cents from industry; the relative difference is due to the large amount of processing which food grains receive after they leave the farm and before they reach the consumer. The greatest portion of the 57 cents, 27 cents or about 50 percent, is from the Great Plains. In contrast, $1 of final demand for fruits and vegetables from the agricultural processing sector is associated with 54 cents of output from agriculture and 70 cents from industry. The largest portion of the 54 cents is from the Pacific States, which contribute 20 cents or about 40 percent of the total.

Other interdependence relationships are explained in...
the text, as they relate both pairs of agricultural sectors and sectors of agriculture and industry.

Farm and nonfarm outputs needed to meet projected 1960 and 1975 final demands for processing industries are estimated within the analytical framework and the limitations of the input-output model. Projected demands for agricultural goods for 1960 indicate a required volume of farm output about 7 percent greater than 1954 and a required volume of industrial output approximately 2 percent greater than 1954, with the industrial output being only that associated with changes in agriculture. Likewise, projected demand for agricultural processing goods for 1975 indicates that farm output would need to be 28 percent greater than in 1954 and that industrial output, to meet the needs of agriculture, would need to be about 6 percent greater than total industrial output in 1954. Economic implications of the fixed and linear production coefficients used for the input-output projections are reviewed in the text.

Although the tables presented provide a basis for certain agricultural policy decisions, there is need for improvements in various facets of the model. Additional research in determining component parts of margins associated with agricultural inputs and outputs, by regions or states, would be useful in constructing future transaction tables. Estimation of machinery use for agricultural sectors should have additional study. Also, the development of improved methods and procedures for allocating inputs among product groups in agriculture would be very useful.

Supplementary tables A, B, C and D (13 sheets, 17 x 22 inches) are available on request from the senior author, Department of Economics and Sociology, Iowa State University, Ames, Iowa.
An Input-Output Analysis Emphasizing Regional and Commodity Sectors of Agriculture

BY HAROLD O. CARTER AND EARL O. HEADY

During the past one and one-half centuries, farming has gradually evolved from a self-sufficient entity or way of life to the status of "farm business." It is now closely interwoven with all other facets of economic activity. Many of the qualitative aspects of these relationships are well known. For instance, it is recognized that good and lean times in agriculture are associated with business conditions in nonagricultural sectors of the economy. Also, regional patterns of production and consumption of goods and services indicate general dependence of some agricultural regions on others for feed, livestock and farm supplies. However, knowledge of exact quantitative interrelationships is limited. With increased governmental activity in agriculture, quantitative information on the economic interdependence among agricultural regions and between agriculture and the rest of the economy will be growing in importance over the next decade.

This study has been designed to derive interdependence coefficients among different regional and crop sectors of American agriculture and among agricultural and industrial sectors. In deriving these quantities, the empirical method known as input-output analysis has been used.

OBJECTIVES

The over-all purpose of this study is to quantify the interrelationships and degree of interdependence among various regional and commodity sectors of agriculture, as well as between these sectors and industrial sectors of the economy. Knowledge of these descriptive interrelationships is important in determining how one sector of agriculture might be affected by economic changes or policies which cause changes in other sectors of the economy. While certain projections are made, within the framework and limitations of model developed, these are considered subordinate to the main purpose of deriving interrelationships of economic sectors at a particular point in time.

More specific objectives of this study are:

1. To formulate a structural model of input-output relationships applicable to agricultural regions and other sectors of the economy.
2. To use presently available statistics for making an empirical application of the input-output technique by estimating physical and value flows of trade patterns among agricultural regions and between agriculture and industry for the year 1954.
3. To interpret, in terms of present and projected agricultural conditions and problems, coefficients (1) summarizing the cost structures of economic sectors and (2) expressing the interrelationships between each sector and the final bill of goods.
4. To appraise the validity of the theoretical assumptions of the input-output model when applied to a study of regional agricultural relationships and develop suggestions for improving classification and aggregation of inputs and outputs of the various sectors.

NATURE OF INPUT-OUTPUT ANALYSIS

Input-output accounts provide a concise and systematic arrangement of economic activity. They allow the goods and services associated with each industry to be identified as sales or purchases, depending on whether they are outputs or inputs, respectively. Input-output analysis consists of using these quantitative relationships to investigate and analyze various operations of the economy and to derive interdependence coefficients among various economic sectors included in the model.

HISTORICAL BACKGROUND

Several empirical input-output studies have been made over the last 15 years in the United States and other countries. Major emphasis in past studies was on assembling the accounts, rather than on analytical aspects of the model.

Leontief developed the input-output method and made the first empirical study: an analysis of the American economy over the period 1919-29, published in 1941 (34). He also constructed an input-output table for 1939 (35, table 24). A more elaborate input-output table was constructed by the United States Bureau of
Labor Statistics for 1947 (16). Other national studies have been made for Canada, Denmark, France, Germany, Austria, Great Britain, Israel, Italy, the Netherlands, Norway and the USSR.

Regional input-output models were developed by Isard (28), Moses (39) and Chenery (11). Regional models define industries spatially as well as by type of product or service produced. Peterson and Heady (45) constructed a five-sector model of the United States economy for 1949, 1939, and 1929, stressing agriculture. Schnitker and Heady (48) expanded on Peterson's work in constructing a regional model of agriculture for 1949. The latter model considered six regions subdivided into primary and secondary agriculture and six national industry sectors.

**INPUT-OUTPUT METHODS AND LOGIC**

**Theoretical Framework Used**

In input-output analysis, the economy is divided into a number of sectors, each of which not only purchases goods and services from other sectors but also produces goods and services which are sold to other sectors. If all sectors are both producers and consumers, the system is represented by a "closed" model; i.e., all sectors are assumed to be interdependent with functionally related inputs and outputs. In a closed model, for example, households constitute an industry whose output is labor services and whose inputs are consumption goods such as food, shelter, medicine, recreation, etc. Under the necessary input-output assumptions of constant technical ratios, this procedure implies that a man-hour of labor requires a fixed mix of consumption goods.

If, on the other hand, some sectors are related to other sectors but are not functionally dependent upon them, the system is "open." In this case, final demand (i.e., exports, government, service and household consumer goods) is autonomously determined by factors outside the system. Labor and managerial services then are considered as inputs but not as functionally related products of the household sector.

Prior to World War II, input-output analysis dealt only with closed models, the objective being determination of the necessary production from each sector to meet the input requirements of all other sectors. Subsequently, emphasis has shifted to the open models which are more applicable in determining levels of sector outputs consistent with a specified final or consumer demand. An open model is used in this study.

An open model of the economy can be expressed by a set of linear equations describing inter-sector flows of goods and services as in equation 1:

\[
\begin{aligned}
X_1 &= x_{11} + x_{12} + x_{13} + \ldots + x_{1n} + Y_1 \\
X_2 &= x_{21} + x_{22} + x_{23} + \ldots + x_{2n} + Y_2 \\
X_3 &= x_{31} + x_{32} + x_{33} + \ldots + x_{3n} + Y_3 \\
\vdots & \vdots \\
X_n &= x_{n1} + x_{n2} + x_{n3} + \ldots + x_{nn} + Y_n
\end{aligned}
\]

(1)

where, \(i, j = 1, 2, 3 \ldots n\), \(X_i\) is the output of sector \(i\), \(x_{ij}\) is the total amount of output of sector \(i\) purchased by industry \(j\), and \(Y_i\) denotes the final or consumer demand for goods of industry \(i\). If the \(x_{ij}\) for \(i = j\) are excluded, output is a "net" quantity. With \(x_{ij}\) included for all \(ij\), the output is a "gross" quantity.

The basic assumption made in input-output analysis pertains to the relation between purchases of an endogenous sector and the level of output of this sector. Assuming a linear relationship, the equation defining \(x_{ij}\) is:

\[
(2a) \quad x_{ij} = a_{ij}X_j + c_{ij}
\]

where \(a_{ij}\) and \(c_{ij}\) are constants to be explained later.

For all empirical work, the additional assumption is made that \(c_{ij}\) is equal to zero. Hence, \(a_{ij}\) (referred to as an input-output coefficient) can be measured from a single observation of the ratio between \(x_{ij}\) and \(X_j\) written as

\[
(2b) \quad a_{ij} = x_{ij}/X_j
\]

Substituting equation 2a, assuming \(c_{ij} = 0\), into 1 yields:

\[
\begin{aligned}
X_1 &= a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots + a_{1n}X_n + Y_1 \\
X_2 &= a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots + a_{2n}X_n + Y_2 \\
X_3 &= a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + \ldots + a_{3n}X_n + Y_3 \\
\vdots & \vdots \\
X_n &= a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 + \ldots + a_{nn}X_n + Y_n
\end{aligned}
\]

(3a)

or in matrix notation

\[
(3b) \quad X = AX + Y
\]

where \(X\) is a vector of sector outputs, \(A\) is a matrix of input-output coefficients, and \(Y\) is a vector of final demand quantities.

Hence, with specified final demands \(Y_1, Y_2, Y_3, \ldots, Y_n\) and constant input-output coefficients, \(a_{ij}\), equations 3a can be solved for the outputs, \(X_1, X_2, \ldots, X_n\) needed to supply specified deliveries to final demand. Technically, the solution is the inverse of the difference between an identity matrix and the input-output coefficient matrix multiplied by a final demand vector. The resulting system of equations is given in 4a where \(A_{ij}\) is an element of the inverse matrix \((I-A)^{-1}\).

\[
\begin{aligned}
X_1 &= A_{11}Y_1 + A_{12}Y_2 + A_{13}Y_3 + \ldots + A_{1n}Y_n \\
X_2 &= A_{21}Y_1 + A_{22}Y_2 + A_{23}Y_3 + \ldots + A_{2n}Y_n \\
X_3 &= A_{31}Y_1 + A_{32}Y_2 + A_{33}Y_3 + \ldots + A_{3n}Y_n \\
\vdots & \vdots \\
X_n &= A_{n1}Y_1 + A_{n2}Y_2 + A_{n3}Y_3 + \ldots + A_{nn}Y_n
\end{aligned}
\]

(4a)

\[
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X_1 &= A_{11}Y_1 + A_{12}Y_2 + A_{13}Y_3 + \ldots + A_{1n}Y_n \\
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X_3 &= A_{31}Y_1 + A_{32}Y_2 + A_{33}Y_3 + \ldots + A_{3n}Y_n \\
\vdots & \vdots \\
X_n &= A_{n1}Y_1 + A_{n2}Y_2 + A_{n3}Y_3 + \ldots + A_{nn}Y_n
\end{aligned}
\]

For many input-output studies intra-industry flows (i.e., distribution of the \(i\)-th good to the \(j\)-th industry) were excluded because of the unavailability of adequate data. However, it is possible to transform "net" to "gross" outputs for the input-output coefficient matrix by the inverse matrix (37, p. 89). Inverse coefficients in "gross" terms reveal additional economic information not given by "net" inverse coefficients. That is, "gross" inverse coefficients quantify the impact on an industry in order to fulfill increased demands for its products. Accordingly, "gross" flows were used in this study.

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or in matrix notation

\[(4b) \quad X = (I - A)^{-1}Y\]

The $A_{ij}$'s in $4a$ are interdependence coefficients. Interdependence coefficients specify the required change in gross output of industry $i$ for a one-unit change in the amount of goods delivered to final demand by industry $j$.

**Numerical Example**

This section provides a numerical counterpart to the general mathematical model given in the previous section. Using an oversimplified two-sector aggregate of the economy, quantitative flows are summarized; input-output and interdependence coefficients are derived for actual 1954 data of the United States.

**A Two-Sector Transaction Matrix**

The economy is aggregated into three sectors—agriculture, industry, and households for 1954. Agriculture ($X_1$) and industry ($X_2$) are endogenous, whereas the household sector ($Y$) is exogenous. Data in table 1 are the quantitative counterpart of equations 1. For example, $X_1 = 41$, $X_{11} = 11$, $X_{12} = 25$ and $Y_1 = 5$.

Row 1 in table 1 shows that gross output of agriculture was 41 billion dollars; internal purchases of agriculture (e.g., home-grown feed for livestock) were 11 billion dollars; purchases of industry (e.g., cattle shipped to meat packing plants) from agriculture were 25 billion dollars; purchases for final consumption (household) from agriculture (e.g., home-grown garden vegetables and fruit) were 5 billion dollars. Similarly, row 2 shows the allocation of gross output for industry. Gross output of industry was 518 billion dollars. Industry output purchased by agriculture (e.g., gasoline and oil, prepared feeds, etc.) was 13 billion dollars. Intra-sector flows of industry were 224 billion dollars. Consumption by households of industry products (e.g., canned vegetables and fruit, automobiles, etc.) was 281 billion dollars.

Each column gives a summary of purchases of the sector named in the column heading. For example, 11 billion dollars of inputs from agriculture was required to enable agriculture to produce 41 billion dollars of output. Likewise, agriculture required 13 billion dollars from industry and 17 billion dollars of labor services from households (column 1, rows 2 and 3) respectively. Entries in column 2 show the cost structure of industry (sector 2). To produce 518 billion dollars of output, industry required 25 billion dollars of agricultural products (column 2, row 1), 224 billion dollars of internal transactions (column 2, row 2) and 269 billion dollars of labor services. Similarly, column 3 shows the cost structure of the household sector.

**Input-Output Coefficients**

The unit cost structure or input-output coefficient of each sector is shown in table 2. Each ratio (input-output coefficient) in table 2 was calculated directly from data in table 1 using equation 2b. For example, internal flows in agriculture of 11 billion dollars divided by 41 billion dollars (total output of agriculture) yields 0.27, the entry at row 1 and column 1 in table 2.

The ratios in table 2 are interpreted as follows: Each $1 of output produced by agriculture in 1954 required 27 cents in materials or inputs from within agriculture; 32 cents in materials from industry and 41 cents of labor from households. Similarly, each $1 of output from industry used 5 cents of products from agriculture, 43 cents of products from within industry and 52 cents of labor from households.

**Input-Output Solution**

The input-output coefficients derived in table 2 for the simple illustrative model can indicate the method for deriving interdependence coefficients, a major objective of this study. The coefficients in table 2 serve as the $a_{ij}$'s of equation system 3a. Substituting in these values, we have:

\[X_1 - .27X_1 - .05X_2 = Y_1\]

\[(5a)\]

\[X_2 - .32X_1 - .43X_2 = Y_2\]

which reduced gives:

\[(1 - .27)X_1 - .05X_2 = Y_1\]

\[(5b)\]

\[-.32X_1 + (1 - .43)X_2 = Y_2\]

or in matrix notation

\[
\begin{bmatrix}
1 - .27 & - .05 \\
-.32 & 1 - .43
\end{bmatrix}
\begin{bmatrix}
X_1 \\
X_2
\end{bmatrix}
= 
\begin{bmatrix}
Y_1 \\
Y_2
\end{bmatrix}
\]
Hence, solving for outputs $X_1$ and $X_2$ specifying $Y_1$ and $Y_2$ gives:

$$
(6a) \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1 & -0.27 \\ -0.32 & 1 \end{bmatrix}^{-1} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}
$$

and in standard form comparable to equations 4a in the preceding section:

$$
(6b) \begin{align*}
X_1 &= 1.42Y_1 + 0.12Y_2 \\
X_2 &= 0.80Y_1 + 1.82Y_2
\end{align*}
$$

The $-1$ superscript in 6a indicates that this matrix is to be inverted. The arithmetic coefficients in 6b have been so obtained and are the numerical equivalent of the $A_{ij}$'s in 4a. These elements of the inverse matrix, i.e., the numbers in 6b, are the interdependence coefficients to be derived as a basic objective of the study. The interdependence coefficients show the magnitude of output "required" from one industry when demand for products of another (or the same) industry increase by $1$.

Briefly, the interpretation of 6b is: Output of agriculture ($X_1$) is a function of (depends on) final demand for agricultural goods ($Y_1$) and industry goods ($Y_2$). This function is quantified by deriving the interdependence coefficients. A similar equation applies to industry output ($X_2$). For each $1$ in final demand for products of agriculture required in 1954, a gross output of agriculture amounting to $1.42$ and a gross output of industry amounting to $80$ cents were produced. Likewise, the delivery of $1$ of industry goods in aggregate to final demand required an output of $12$ cents from agriculture and an output of $1.82$ from industry itself.

The main focus of this study is in characterizing the interrelationships among agricultural and other sectors. However, the system is sometimes used to predict total output from particular sectors which would be required if demand were to change to given levels. While this use is not made of the input-output system in this study, the procedure is indicated below for the small illustrative model. For these purposes, we arbitrarily suppose that final or direct demand for agricultural products increases from 5 to 8 billion dollars and that demand for industrial goods increases from 281 to 350 billion dollars. The resulting outputs, 53.4 billion dollars of agricultural products and 643.4 billion dollars of industrial goods, are derived by substituting the demand quantities into equation 6b as follows:

$$
\begin{align*}
X_1 &= 1.42(8) + 0.12(350) = 53.36 \\
X_2 &= 0.80(8) + 1.82(350) = 643.40
\end{align*}
$$

As direct demand for products from one sector increases, output of this sector necessarily increases. However, there also is an indirect or circular demand for output from this particular sector, as direct demand for the product of another sector increases. The total demand effects, including those arising directly for the product of a sector and those arising indirectly as demand for products of another sector increases, can be illustrated by using the technical coefficients of table 2. Quite obviously, delivery of the quantity of $Y_1$ and $Y_2$ goods to final demand by sectors 1 and 2 requires outputs of the same magnitudes from agriculture and industry, respectively. In addition to the direct demand of $Y_1$, for output from sector 1, this sector also needs to produce products to be used as "expenses" for the two sectors, an indirect amount equal to $a_{11}Y_1 + a_{12}Y_2$. For the same reason, sector 2 must not only produce $Y_2$ for direct demand but also $a_{21}Y_1 + a_{22}Y_2$ as an indirect requirement. These additions, the indirect additions explained above, are considered to be first-round requirements or effects. Total circular or indirect requirements are derived as the sum of the second-, third-, fourth-, etc., round requirements. Second-round requirements for $X_1$ and $X_2$ are additional gross output generated from first-round requirements. Algebraically, second-round requirements for $X_1$ and $X_2$ are given in equations 7a and 7b, respectively.

$$
\begin{align*}
X_1^{(2)} &= a_{11}X_1^{(1)} + a_{12}X_2^{(1)} = a_{11}(a_{11}Y_1 + a_{12}Y_2) + a_{12}(a_{21}Y_1 + a_{22}Y_2) \\
X_2^{(2)} &= a_{21}X_1^{(1)} + a_{22}X_2^{(1)} = a_{21}(a_{11}Y_1 + a_{12}Y_2) + a_{22}(a_{21}Y_1 + a_{22}Y_2)
\end{align*}
$$

where the exponent in parentheses denotes the "round" of input requirements.

The third-round requirements (i.e., the additional gross output generated from second-round requirements) are:

$$
\begin{align*}
X_1^{(3)} &= a_{11}X_1^{(2)} + a_{12}X_2^{(2)} = a_{11}[(a_{11}Y_1 + a_{12}Y_2) + a_{12}(a_{21}Y_1 + a_{22}Y_2)] + a_{12}[(a_{21}Y_1 + a_{22}Y_2)] \\
X_2^{(3)} &= a_{21}X_1^{(2)} + a_{22}X_2^{(2)} = a_{21}[(a_{11}Y_1 + a_{12}Y_2) + a_{12}(a_{21}Y_1 + a_{22}Y_2)] + a_{22}[(a_{21}Y_1 + a_{22}Y_2)]
\end{align*}
$$

Continuing ad infinitum, the $r$th round can be written from the $r-1$ round as follows:

---

9For a simple case such as this, the inverse matrix may be solved using algebra. The following definition is presented:

$$
\begin{align*}
(I-A)(I-A)^{-1} &= I \\
(I-A) &= \begin{bmatrix} 0.73 & -0.05 \\ -0.32 & 0.57 \end{bmatrix}, \quad (I-A)^{-1} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}
\end{align*}
$$

and the identity matrix is:

$$
I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}
$$

Hence the definition is:

$$
\begin{align*}
\begin{bmatrix} 0.73 & -0.05 \\ -0.32 & 0.57 \end{bmatrix} \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} &= \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}
\end{align*}
$$

By matrix multiplication:

$$
\begin{align*}
0.73A_{11} - 0.05A_{12} &= 1 \\
-0.32A_{11} + 0.57A_{12} &= 0 \\
0.73A_{21} - 0.05A_{22} &= 0 \\
-0.32A_{21} + 0.57A_{22} &= 1
\end{align*}
$$

By eliminating variables, the interdependence coefficients ($a_{ij}$'s) are obtained as: $A_{11} = 1.42$, $A_{12} = 0.12$, $A_{21} = 0.80$, $A_{22} = 1.82$.
(9a) \( X_1^{(r)} = a_{11}X_1^{(r-1)} + a_{12}X_2^{(r-1)} \)

(9b) \( X_2^{(r)} = a_{21}X_1^{(r-1)} + a_{22}X_2^{(r-1)} \)

Summing rounds 1 to infinity and factoring out \( Y \) yields the final form of the solution:

(10a) \[
X_1^{(r)} = (1 + a_{11} + a_{12}a_{21} + a_{11}a_{12}a_{21} + a_{12}a_{21}a_{22} + \ldots) Y_1 + (a_{12} + a_{11}a_{12} + a_{11}a_{12}a_{21} + a_{12}a_{21}a_{22} + \ldots) Y_2
\]

(10b) \[
X_2^{(r)} = (a_{21} + a_{21}a_{11} + a_{21}a_{21} + a_{21}a_{12} + a_{21}a_{21}a_{12} + a_{21}a_{21}a_{22}a_{21} + a_{21}a_{22}a_{21}a_{22} + \ldots) Y_1 + (1 + a_{21} + a_{21}a_{22} + a_{21}a_{22}a_{21} + a_{21}a_{22}a_{21}a_{22}a_{21} + \ldots) Y_2
\]

The \( A_{ij} \)'s derived in 10a and 10b are identical to interdependence coefficients derived from the inverse of the I-A matrix.

The values \( Y_1 = 8 \) and \( Y_2 = 350 \) were substituted into equations 9a and 9b in deriving output magnitudes for \( X_1 \) and \( X_2 \) for the first five rounds. The results are shown in table 3.

It is evident from table 3 that successive iterations generate increasingly less output. After five rounds the sum is nearly identical with the "inverse" solution.6

Problems of aggregation, constant coefficients, valuation, substitution possibilities and difficulties in models emphasizing agriculture have been discussed elsewhere (45, 48). Hence they are not discussed here.

**THE 1954 MODEL**

A major objective of this study is to gain quantitative information on economic interrelationships among agricultural regions and between agriculture and the rest of the economy. This objective, together with knowledge of available data, was a guidepost for formulating the model in this study. The sections immediately following consider (1) regional and sector classification of the economic model and (2) the mathematical formulation of the model. The major tables of empirical results are presented in the supplement available for this study. The implications of the results in these supplemental tables are discussed in the text which follows.

**REGIONAL AND SECTOR CLASSIFICATION**

Initial decisions made in constructing a regional input-output model include (1) selecting a base period, (2) defining regional boundaries and (3) defining endogenous and exogenous sectors. Each of these problems is discussed briefly in the following section.

**SELECTING A BASE PERIOD**

This study was initiated in 1956. Consequently, 1954 was the most recent year with adequate published data on the United States economy. Selection of 1954 as the period for study made the 1954 Census of Agriculture (52), 1954 Census of Manufactures (55) and other government publications prior to 1956 the only ones available for the analysis which follows.

**DEFINING REGIONAL BOUNDARIES**

The regional boundaries established for agriculture coincide with the 10 types of farming regions used by the Agricultural Research Service, United States Department of Agriculture. Composition of these regions by states is given in table 4. The regions are outlined in fig. 1. These regions, although not conforming to all aggregation principles, delineate approximately uniform farm production areas in the United States. It is recognized, of course, that each region produces some quantity of most agricultural products.

---

6The algebraic equivalence of the two solutions is proved by Dorfman, et al. (14, p. 216).

---

**TABLE 3. SUMMARY OF THE FIRST FIVE ROUNDS RESULTING FROM A SPECIFIED FINAL DEMAND OF \( Y_1 = 8 \) AND \( Y_2 = 350 \).**

<table>
<thead>
<tr>
<th></th>
<th>1st round</th>
<th>2nd round</th>
<th>3rd round</th>
<th>4th round</th>
<th>5th round</th>
<th>Final round</th>
<th>Total sum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>effect</td>
<td>effect</td>
<td>effect</td>
<td>effect</td>
<td>effect</td>
<td>effect</td>
<td></td>
</tr>
<tr>
<td>( X_1 ) (Agriculture)</td>
<td>19.66</td>
<td>12.96</td>
<td>7.10</td>
<td>3.67</td>
<td>1.86</td>
<td>8.00</td>
<td>53.25</td>
</tr>
<tr>
<td>( X_2 ) (Industry)</td>
<td>153.06</td>
<td>72.11</td>
<td>35.15</td>
<td>17.39</td>
<td>8.65</td>
<td>53.00</td>
<td>656.56</td>
</tr>
</tbody>
</table>

---

1Recommendations made before the Subcommittee on Economic Statistics were that an abbreviated interindustry table be constructed on the basis of 1954 census data, and a fairly detailed input-output table constructed on the basis of the 1958 economic censuses (56b, p. 247).
TABLE 4. AGRICULTURAL REGIONS BY STATES

<table>
<thead>
<tr>
<th>Region</th>
<th>STATE</th>
<th>Region</th>
<th>STATE</th>
<th>Region</th>
<th>STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTHEAST</td>
<td>Maine</td>
<td>NORTHEAST</td>
<td>Maine</td>
<td>NORTHEAST</td>
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<td>SOUTHEAST</td>
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<td>Kansas</td>
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Commodity groups within agricultural regions

Two types of aggregation are feasible for agricultural sectors: (1) classification by products and (2) classification by enterprises. The product basis is used in this study because of the form of available data. Except for fragments, all agricultural statistics are published on a commodity or product basis. Independent of data limitations, both classification schemes have disadvantages. The main objection to an enterprise classification is that output and input composition varies to an extent that coefficients are not uniquely defined. For example, dairy farmers produce both cash and feed crops. Too, cash crop farmers raise a certain amount of livestock in addition to crops. The proportions within each farm vary over time depending on relevant price relationships and individual preferences. Product groupings also have disadvantages: Large numbers of agricultural commodities are joint products. The distribution of inputs among commodity groups is difficult and sometimes arbitrary. There is no established basis for allocating inputs such as machinery, building depreciation, petroleum products, etc., among individual products.

For this study, however, available data dictated the product or commodity groupings. Agricultural commodities are divided into nine groups within each region. These are:

ISC i.1 Livestock and livestock products—meat animals, dairy products, poultry and eggs and miscellaneous livestock products.

ISC i.2 Feed grains—corn, oats, barley and grain sorghum.

ISC i.3 Food grains—wheat, rice, rye and buckwheat.

ISC i.4 Forage crops—hay, pasture, and grass and legume seeds.

ISC i.5 Vegetables and fruit—vegetables, fruits and nuts.

ISC i.6 Cotton—cotton lint and cottonseed.

ISC i.7 Tobacco—unmanufactured tobacco.

ISC i.8 Oil crops—soybeans, peanuts, flaxseed and tung nuts.

ISC i.9 Miscellaneous agriculture—sugar crops, miscellaneous crops, forest, nursery and greenhouse products, horses and mules services, and other agricultural services.

Commodity groups are numbered 1 through 9, and i designates regions (i = 0, 1, 2, ... 10) where zero denotes a national group and 1, 2, ... 10 denote regional groups. For example, 1.1 denotes livestock (product 1) in the Northeast (region 1); livestock in the United States is denoted by 0.1. Ten agricultural regions with nine commodity groups per region made a total of 90 possible sectors in the agricultural section of the model. However, cotton production is negligible in regions 1, 3 and 8, and tobacco is not produced in regions 6, 7, 8, 9 and 10. Thus 82 “live” or nonzero sectors are in the agricultural section of the model.

Industry sectors are defined on a national basis. Three major categories of industries are identified: (a) industries processing agricultural products (sectors 0.10 through 0.17), (b) industries furnishing agriculture with major factor inputs (sectors 0.18 through 0.21) and (c) a single sector to represent all other industries (sector 0.22). Individual agricultural industries are defined comparable to sectors in the input-output model constructed by the Bureau of Labor Statistics (98) for 1947.8

Composition detail for each industry is briefly listed below. Additional details are available in Appendix A.

---

8See Appendix A for the correspondence between sectors defined in this study and the EM classification used in the Bureau of Labor Statistics study.
ISC 0.10 Meat and poultry processing—meat packing and prepared meats, products from poultry dressing plants and poultry products involving minor processing.

ISC 0.11 Dairy products—creamery butter, natural cheese, concentrated milk, ice cream and ice, special dairy products and fluid milk.

ISC 0.12 Grain processing—flour and meal, cereal preparations, rice cleaning and blended and prepared flours.

ISC 0.13 Prepared feeds—a—livestock feeds from mixers and manufacturers.

ISC 0.14 Miscellaneous food processing—miscellaneous food preparations, beverages, bakery and related products and confectionery and related products.

ISC 0.15 Vegetable and fruit processing—canned and frozen fruits and vegetables, and fruits and vegetables with minor processing.

ISC 0.16 Tobacco manufacturing—cigarettes, cigars, chewing and smoking tobacco and tobacco stemming and redrying.

ISC 0.17 Textile products—woolen and worsted manufacturing, cotton and rayon textiles, carpets, rugs and miscellaneous textile goods.

ISC 0.18 Fertilizers—fertilizer and fertilizer mixing.

ISC 0.19 Chemical products—chemicals, paints and varnishes, soap and related products, drugs and medicines and vegetable and animal oils.

ISC 0.20 Machinery and related services—tractors, farm machinery, motor vehicles and related services.

ISC 0.21 Petroleum products—gasoline, oil and grease.

ISC 0.22 All other industries—This sector includes all other products not listed above. The major products purchased by agriculture are wholesale and retail trade, transportation, veterinary services and miscellaneous supplies.

The zero preceding the decimal in the sector number denotes a national industry. Seven sectors are classified as "processing industries," five as "furnishing industries" and a single aggregate as "all other industries."

Final demand sectors

Final demand represents sectors whose flows are non-structurally interrelated, or exogenous, to the input-output system. Components of final demand are foreign trade (export and import), government, inventories and household.

Foreign trade. Foreign trade sectors are essentially a summary of transactions with foreign countries. Exports include sales of goods and services from United States sectors for use abroad. It is assumed that all imports are substitutable for some domestic product, and hence they are treated as competitive. Imports are distributed as if they are secondary products of foreign trade and channeled to the industries for which their products are primary.

Government. Government outputs are services rendered represented by the amount of taxes paid by each sector of the economy. Inputs to government are governmental purchases of goods and services from other sectors. Government subsidies are treated as transfer payments to household. The accounts of sectors receiving subsidies are affected only by the amount that profit levels are understated when receipts of the subsidies are excluded from the income of these sectors. Payments to the household sector are not affected in total since households receive all profits in addition to transfer payments. Of course, government operation of price support programs provides an indirect subsidy to various producers, which in turn is stated in market price.

Inventory. Inventory accounts are established to facilitate reconciliation of current production with current consumption. The inventory sector is a consumer of goods whenever additions to domestic stocks are made, but it becomes a supplier of goods whenever goods are consumed out of reserve stocks.

For agricultural sectors, inventories are divided into three categories: (1) producing sector, (2) Commodity Credit Corporation and (3) others. The inventory changes in the producing sector are farm-owned stocks; CCC stocks include goods held by CCC on farms, in private elevators and in government-owned storage. Other inventories include goods held by private industry.

Inventories for national industries include only finished goods held by the producing sector. No attempt is made to locate finished industrial goods of sector i held by sector j.

Household. Private individual expenditures for goods and services appear in this model as purchases by the household sector. Personal living expenditures by farm households are included, but costs of farm operation are excluded. Household flows to other sectors are factor payments such as wages and salary, proprietor's income, depreciation and other miscellaneous items.

Additional details on each of the final demand sectors are presented in Appendix A.

Mathematical formulation of the model

The preceding section reviewed the regional and sector classification. This section describes the mathematical formulation of the input-output model used in this study.

Given that k, s denote regions; i, j denote commodity groups within regions; and h, r denote national industries, the allocation of the output X^s_i to any commodity group j within region s and industry r can be described by equations 11a.

---

9The prepared feed industry is somewhat of a dual-purpose industry since it both processes grain and furnishes large quantities of formula feeds to agricultural sectors. In the economic sense it is classified as a furnishing industry.

10The terms "bill of goods" and "autonomous flows" are synonymous with exogenous flows.

11See foreign trade section in Appendix A for more complete details.
or more concisely as,

\[ X^k_i = \sum_{s} x^s_{ij}a_{ij} + \sum_{r} x^r_{i1}r + Y^k_i \]  

(11b)

\[ X^h_s = \sum_{j} x^s_{hj} + \sum_{r} x^{kr}_{hr}Y^h_s \]

where \( i, j = 1, 2, \ldots 9; h, r = 10, 11, \ldots 22; k, s = 1, 2, \ldots 10 \).

From equations 11a, \( X^2_1 \) denotes the output of commodity 1 (livestock) in region 2 (Corn Belt); \( x^{k,x}_{2,1} \) denotes the value of commodity 2 (feed grains) produced in region 1 (Northeast) consumed by commodity 1 (livestock) in region 2 (Corn Belt); \( x^{s,x}_{22,10} \) denotes the value of national sector 22 (all other industries) goods consumed by commodity 9 (miscellaneous agriculture) in region 10 (Pacific States). \( Y^1_i \) denotes the final bill of goods for commodity 1 (livestock) in region 1 (Northeast).

Assuming constant production coefficients gives:

\[ x^{k,a}_{ij} = a^{k,a}_{ij}x^a_{ij}, \quad x^{k,l}_{ir} = a^{k,l}_{ir}X_r \]  

(12)

\[ x^{h,b}_{hj} = a^{h,b}_{hj}X^b_{hj}, \quad x^{h,r}_{hr} = a^{h,r}_{hr}X_r \]

Substituting 12 into 11a yields in a concise form:

\[ X^k_i - \sum_{s} x^s_{ij}a^{x}_{ij} + \sum_{r} x^r_{i1}r = Y^k_i \]  

(13)

\[ X^h_s - \sum_{j} x^s_{hj}a^{b}_{hj} + \sum_{r} x^{kr}_{hr}Y^h_s = Y^h_s \]

where \( i, j = 1, 2, \ldots 9; h, r = 10, 11, \ldots 22; k, s = 1, 2, \ldots 10 \).

Solving 13 for the required outputs of each sector in terms of \( Y^k_i \) and \( Y^h_s \) gives:

\[ X^k_i = \sum_{s} a^{k,a}_{ij}Y^a_i + \sum_{r} a^{k,l}_{ir}Y^r_i \]  

(14)

\[ X^h_s = \sum_{j} a^{h,b}_{hj}Y^b_s + \sum_{r} a^{h,r}_{hr}Y^r_s \]

where \( i, j = 1, 2, \ldots 9; h, r = 10, 11, \ldots 22; k, s = 1, 2, \ldots 10 \); and

\[ A^{a}_{ij}, A^{b}_{hj}, A^{l}_{ir} \] and \( A^{r}_{hr} \)

are elements in the inverse of the input coefficient matrix 13.

ECONOMIC IMPLICATIONS OF THE MODEL

The supplemental tables A, B and C with this bulletin give an over-all picture of the United States economy in 1954, defined in terms of special characteristics. These tables include the flow matrix, the technical coefficients and the interdependence coefficient (the inverse matrix) for the model outlined above. These tables are presented as separate supplements because of their size and the difficulty of including them in this bulletin. Each table illustrates a slightly different view of the structure of the economy while emphasizing the...
interdependence, a key characteristic of a complex society. Tables A, B and C represent the main empirical effort of this study. They allow many interpretations which are valuable for policies and decisions relating to agriculture. However, this single publication cannot assemble all possible interpretations that can be made, particularly from tables B and C. Hence, the procedure followed in the remaining sections of this study is to summarize some of the more important relationships from the basic matrices, and to use matrices of smaller order for certain other comparisons. The methods used in deriving tables A, B, C and D are explained in Appendix A.

Of course, any analysis or interpretation of specific sectors must be viewed in the perspective in which these sectors were constructed, not as individual contributions but as part of a complete model. Transactions of each sector were built up, using results published by research workers in various specialized fields. Hence this study does not supplant any partial analysis of particular sectors or portions of sectors, but provides a common framework from which specific endeavors can be visualized in relation to the whole.

**Transaction Patterns**

**Pattern of Sales**

Table A presents the summary of sales of each sector (reading across the rows). The purchases of each sector are available by reading down the columns. The pattern of sales varies with each sector. Some sectors have "large" interindustry sales with "small" sales to final demand. Other sectors show little or no interindustry sales but large sales to final demand.

The pattern of sales is illustrated in table 5 where all sectors in agriculture are aggregated into a single sector. Likewise, all industry sectors are aggregated into a single sector. However, industry is subdivided into three categories: (1) agricultural processing industries, (2) agricultural furnishing industries and (3) all other industries. The entries in table 5, reading across, indicate the percent of gross output of the sectors named at the left distributed among the sectors named at the top.

For example, agriculture depends on interindustry demand for 61 percent of its sales. Twelve percent of the sales of agriculture go directly to final demand (i.e., household, inventory, etc.). In general, industries whose

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**TABLE 5. PATTERN OF SALES, 1954.**

<table>
<thead>
<tr>
<th>Percentage of total distribution of output to:</th>
<th>Total agriculture</th>
<th>Total industry</th>
<th>Final demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total agriculture</td>
<td>27</td>
<td>61</td>
<td>12</td>
</tr>
<tr>
<td>Total industry</td>
<td>3</td>
<td>45</td>
<td>54</td>
</tr>
<tr>
<td>I Agricultural processing</td>
<td>1</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>II Agricultural furnishing</td>
<td>10</td>
<td>47</td>
<td>70</td>
</tr>
<tr>
<td>III All other</td>
<td>1</td>
<td>44</td>
<td>56</td>
</tr>
</tbody>
</table>

*Includes foreign trade, inventories, government and household.
*Includes ISC sectors 0.1 through 0.9.
*Includes the summation of I, II and III.
*Includes ISC sectors 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17.
*Includes ISC sectors 0.13, 0.18 through 0.21.
*Includes ISC sector 0.22.

---

**Direct Dependence Between Sectors**

The input-output coefficients in table B provide a view of the structure of each sector in terms of a common unit: inputs per dollar of output. The size of tables A, B and C makes it difficult to view some of the more general economic relationships that exist between industry and agriculture and within agriculture as a whole. Hence, to give a reader a better perspective of the economy, supplemental table A of the appendix is aggregated in several broad classifications and input-output coefficients derived therefrom.

**A Two-sector Aggregation**

The broadest aggregation is presented as an example in the "Methods and Logic" section. Endogenous sectors are defined as those of agriculture and industry. Components of final demand are considered as a single exogenous sector, household. Although the last aggregation is too large to be very meaningful, input-output coefficients in table 2 suggest some general relationships.

A dollar of agricultural output requires 32 cents of inputs (directly) from industry. In comparison, $1 of industry output requires 5 cents of agricultural inputs. In other words, dependence of agriculture on industry is much greater than the dependence of industry on agriculture.

**A Four-sector Aggregation**

A "slightly less aggregated" model of the economy is shown in table 6. Agriculture is identified as a single sector, with industry sub-divided into three categories:
III All other ................ 0.13630

*Each entry shows direct purchases from the sector named at the left by the sector named at the top per dollar of output by the latter.

In table 7, industries are divided into three components. These data show that Sector I includes ISC 0.10, 0.11, 0.12, 0.14 through 0.17.

Incluse ISC sectors 0.1 through 0.9.

The sector of furnishing industries, shown in table 6, includes prepared feeds, fertilizers, chemical supplies, machinery and related services and petroleum products. Quite obviously, the magnitude of agricultural output is related closely to these furnishing sectors. In 1954, each dollar's worth of output in agriculture was associated with use of 19 cents of products from furnishing industries. The dependence of agriculture upon industry has been increasing with time, as shown in a previous study (45). However, the opposite relationship is not one of such great empirical importance: $1 of output by furnishing industries required, in the mix of 1954, only 3 cents of agricultural output.

In contrast, processing industries required or used per $1 of output, in 1954, 36 cents of agricultural products. The 36 cents is approximately the farmer's share of the consumer's dollar in 1954. This 36 cents is the direct effect explained earlier. As will be shown later, the indirect effects on agriculture of a change in final demand for products of processing industries also are quite large. On the other hand, agricultural output has but little dependence on inputs from processing industries, with the requirement being less than 1 cent per $1 of agricultural output in 1954.

A 13-SECTOR AGGREGATION

Agriculture was aggregated into 10 type-of-farming regions with industry remaining unchanged from the four-sector aggregation (table 7). Fox and Norcross (18) suggested that agriculture be aggregated according to type of enterprise; e.g., tobacco farms, etc. Although an enterprise classification was not used, it is possible to conceive of agriculture in the type-of-farming region as representative of farms in that area. However, variation in agricultural production exists within regions, and resulting coefficients are analogous to weighted averages.

Agricultural processing industries (i.e., meat and poultry products, dairy products, grain products, miscellaneous food products, vegetable and fruit products, tobacco products and textile products) purchased (as a group) in 1954, 36 cents of agricultural inputs (per $1 of output) 13. The largest purchases were made from the Corn Belt with 8.7 cents and the smallest from the Delta States with 1.6 cents. No explanation is required for the large coefficient connecting Corn Belt agriculture and agricultural processing industries. However, the corresponding small coefficient for the Delta States is related partially to cotton production. That is, 44 percent of the gross output of the Delta States, or 92.6 million dollars, was cotton production (cotton and cottonseed). Almost 25 percent of the cotton sector output (ISC 6.6) was an addition to CCC storage rather than purchases by textile products. (Textile products is a component of sector I in table 7).

Second largest purchases of agricultural processing industries (sector I, table 7) were made from the Pacific States and were valued at 4.4 cents. A majority of these products were livestock and fruit and vegetables.

The relationship of processing and furnishing industries to regional agricultural sectors also is of import-

| TABLE 6. INPUT-OUTPUT COEFFICIENTS. UNITED STATES ECONOMY, 1954*. (AGGREGATION OF TOTAL AGRICULTURAL AND SUBDIVISION OF INDUSTRY.) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Industry | Total agriculture | Agr. proc. II | Agr. proc. II | All other |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total agriculture | 0.26781 | 0.02956 | 0.00060 |
| I Agr. proc. ind | 0.26781 | 0.02956 | 0.00060 |
| II Agr. furnishing | 0.14800 | 0.02839 | 0.00060 |
| III All other | 0.03032 | 0.00120 | 0.00060 |

13This figure was obtained by summing col. I, rows 1 through 10, table 7.

<p>| TABLE 7. INPUT-OUTPUT COEFFICIENTS. UNITED STATES ECONOMY, 1954*. (AGGREGATION OF AGRICULTURAL REGIONS AND INDUSTRY) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agricultural regions | Industry |</p>
<table>
<thead>
<tr>
<th>N. E.</th>
<th>Corn Belt</th>
<th>Lake States</th>
<th>Apalach. States</th>
<th>S. E.</th>
<th>Delta States</th>
<th>S. Plains</th>
<th>N. Plains</th>
<th>Mt. States</th>
<th>Pac. States</th>
<th>Agr. processing</th>
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<tr>
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<td>.00008</td>
<td>.00250</td>
<td>.02296</td>
<td>.00297</td>
<td>.00024</td>
<td>.00007</td>
<td>.00009</td>
<td>.00007</td>
<td>.00003</td>
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<td>.00013</td>
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<td>.00297</td>
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<td>.00009</td>
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</tbody>
</table>

*Each entry shows direct purchases from the sector named at the left by the sector named at the top per dollar of output by the latter.

1I consists of ISC sectors 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17.

II consists of ISC sectors 0.13, 0.18, 0.19, 0.20 and 0.21.

III consists of ISC sector 0.22.
ance: Considering agricultural processing sector purchases (per dollar of output) from broad sections of the United States we have the following quantities: The Northeastern agricultural area (i.e., regions 1, 2 and 3) provided inputs valued at 16 cents for each $1 of output by the processing sector. The Southern area (regions 4, 5 and 6) provided inputs valued at 8 cents. The Great Plains and Western regions (regions 7, 8, 9 and 10) provided inputs valued at 6 cents each, per $1 of output in the processing sector. These results indicate the direct dependence of agricultural processing industries (as a group) upon various sections of the agricultural economy. Of course, the output of the processing sector refers to the entire United States, and the composition of its output and input relates to each region accordingly. Had a processing sector been defined for each regional agricultural sector, the input values for the agricultural sector would have been greater, for the processing sector of this particular region. However, figures for the national processing sector do indicate the relative importance of each regional agricultural sector relative to the national mix of goods from the farmer. Later sections review the impact upon regional agriculture (both direct and indirect) associated with changes in demand for agricultural processing sector products.

Direct dependence of agricultural furnishing sectors (sector II, table 7) on regional agricultural sectors for inputs is of lesser importance. Primary inputs of furnishing industries are feed grains for the prepared feed sector (a minor component of sector II). The dependence of sector II upon agriculture is chiefly as a source of demand for products of the latter. However, even in this respect, agriculture purchases only 10 percent of the gross output of sector II.

The Northeast agricultural region has the greatest dependence upon the national furnishing sector. This region purchases 30 cents worth of products from the furnishing sector per $1 of agricultural output. Industrial purchases by agriculture are relatively high in the Northeast because (1) farms produce specialized products (e.g., fluid milk and cream, broilers, fresh eggs, vegetables and fruit) requiring considerable off-farm inputs and (2) farms are highly mechanized relative to unit size. Specialization and small intensive farms result in a large amount of expensive items for the output of the region.

Purchases from agricultural furnishing sectors (i.e., ISC 0.13, 0.18, 0.19, 0.20 and 0.21) are the lowest in the Corn Belt, amounting to 15.6 cents per $1 of agricultural output. Corn Belt agriculture, in terms of markets, is primarily a livestock-producing area. Moreover, a large portion of the inputs purchased by this livestock sector are feed grains in an unprocessed form. This flow is an internal transfer between the feed grain sector (ISC 2.2) and the livestock sector (ISC 2.1), within the Corn Belt. In contrast, the Northeast agricultural region purchases feed which must move through the industrial or furnishing sector, and thus the region has a greater requirement for these purchased inputs.

Other factors also are important in causing the Corn Belt to have a low relative requirement for inputs from the furnishing sector. The main inputs for livestock production within the Corn Belt are farm-raised feed and breeding or feeding livestock. Crop yields in the region are high relative to the amount of fertilizer and related nonfarm inputs per acre; this factor causes the industrial input per dollar output of crops to be low in the Corn Belt as compared with the Northeast and Southeast. High crop yields per acre also cause the input of machinery, petroleum and related items to be low per dollar of agricultural output, especially in comparison with the Great Plains, but also in comparison with the Northeast and Southeast.

The Mountain States agriculture required inputs from the furnishing sector valued at 15.9 cents per $1 of output. Again this is a relatively small dependence upon inputs from the industrial furnishing sector. Agriculture in the Mountain States is dependent, in part, upon irrigation. In 1954, 62 percent of the farms were classified as irrigated farms. Accordingly, crops grown vary from cotton and citrus fruits to grasses. However, livestock and livestock products account for more than 50 percent of the agricultural income. Relatively more beef and sheep than hogs are produced and again require relatively small industrial input, since their feed comes largely from within the region. Range cattle and sheep are produced on native grasses. The Southern agricultural regions (regions 4, 5 and 6) show high relative purchases of industrial inputs per dollar of output. Part of this stems from the small size of the farm and the intensive crops grown. In 1954, the size of the average farm in regions 4, 5 and 6 was slightly over 100 acres, compared with the national average of 242 acres. Farmers operating smaller units often have large or excessive machinery investments. This causes the input of machinery and related inputs to be high per dollar value of crops produced. In the Southeast, in contrast to the Corn Belt and Mountain States, livestock, using mainly feed inputs from within the region, represents a small proportion of total agricultural output.

Interdependence relationships representing aggregation of the more detailed data presented in supplemental table B have been discussed above. The purpose has been to give the reader a summary but comprehensive picture or description of the input-output structure of the economy. Readers may wish to examine the more detailed figures of table B to determine the relative magnitudes of the coefficients for individual commodity sectors of the various regions with each other and with industrial sectors. The following section includes a discussion of some differential cost situations in agriculture as they relate to regional production techniques.

**TOTAL FEED REQUIREMENTS PER DOLLAR OF LIVESTOCK OUTPUT**

Feed requirements per dollar of livestock output by regions are contained in table B. Total feed inputs are determined by summing the coefficients that appear in the relevant livestock columns (e.g., sector 1.1, 2.1, 3.1, etc.) and the corresponding row sectors that furnish feed inputs. For example, total value of feed inputs used per $1 of livestock output in the Northeast region is 53.7 cents. This figure is obtained by summing the coefficients in: column 1.1 and rows 1.2 and 2.2 (feed grains obtained from within the region and from the Corn Belt, equal to $1.2080); column 1.1 and row 1.4 (forage crops obtained from within the region, equal to 0.3490).
Feed inputs in all regions, per $1 of livestock output, averaged about 50 cents. The difference in composition of the "feed bill" is largely explained by the (1) location of the region and (2) type of livestock produced in each region. The Northeast region purchased, per $1 of livestock output, 28.3 cents of prepared feeds (sector 0.13) and 12 cents of feed grains. In contrast, the Corn Belt, Lake States and Northern Plains regions purchased 34.6, 30.2 and 29 cents of feed grains and 8.9, 7.9 and 6.3 cents of prepared feeds, respectively, per $1 of livestock output. The Northeast is a deficit feed grain area. Also, the Northeast is predominantly a dairy and poultry area requiring large quantities of formula feeds. On the other hand, regions 2, 3 and 8 produce mainly beef, hogs and sheep. These livestock require less formula feeds but depend more on bulky, home-grown grains and forage.

The Mountain States region used only 9.7 cents of feed grain and 9.0 cents of prepared feeds per $1 of livestock output. On the other hand, it used 26.8 cents of forage inputs per $1 of output. This differential, as compared with other regions, again results because of the type of livestock produced in the region. The region is one depending largely on native grasses with most of the livestock shipped out of the region, rather than with grain and prepared feed shipped in, as in the case of the Northeast, Southeast Delta and Pacific regions. The Northern Plains region is somewhat similar, with relatively high inputs of forage and small inputs of prepared feeds per dollar output of livestock. However, more feed grain is produced on irrigated land and is used for cattle and sheep fattening.

Inputs of prepared feeds are relatively important in the Northeast, Appalachian, Southeast, Delta and Southern Plains regions because the more intensive dairy and poultry enterprises rely more on these types of inputs. Too, these sectors are grain-deficit regions and import grain through the manufactured feed sector, ISC 0.13. The Corn Belt and Lake States regions specialize more in types of livestock which make greater use of non-processed grains.

**DIRECT INDUSTRIAL REQUIREMENTS PER DOLLAR OF FEED GRAIN OUTPUT**

Industrial inputs required per dollar of feed grain output by regions are available in table B. They are determined by summing the coefficients in the relevant feed grain volumes (e.g., 1.2, 2.2, 3.2, etc.) and the corresponding *rows sectors* that furnish industrial inputs. For example, total value of industrial inputs used per $1 of feed grain output in the Northeast region is 51.4 cents. This figure is obtained by summing the coefficient in: column 1.2 and row 0.18 (fertilizer purchases equal to $0.08454); column 1.2 and row 0.19 (chemical purchases equal to $0.000147); column 1.2 and row 0.20 (machinery and related services equal to $0.25638); column 1.2 and row 0.21 (petroleum products purchases equal to $0.03618); and column 1.2 and row 0.22 ("all other industry" products and services equal to $0.13118). The magnitude of industrial input coefficients is related to such factors as (a) the distribution of crops making up the feed grain sector in each region (i.e., relative acres of corn, oats, barley and sorghum grain), (b) regional prices received, (c) yield obtained and (d) the type of inputs used.

The sum of industrial inputs per $1 of feed grain output in the United States averaged approximately 53 cents. Purchases of industrial inputs, per $1 value of feed grain output, were 48 cents in the Corn Belt, the lowest figure of all agricultural regions. This result is largely explained by favorable growing conditions which result in high corn yields and types of technology explained earlier. Industrial inputs per dollar of feed grain output tend to be highest in regions with low crop yields per acre and small farms.

Fertilizer inputs per $1 of feed grain output range from a low of 1.8 cents (column 8.2 and row 0.18, table B) in the Northern Plains (region 8) to a high of 15.7 cents (column 5.2 and row 0.18, table B) in the Southeast (region 5). The Northern Plains fertilizer coefficient is small because low rainfall makes high fertilizer applications unprofitable. High fertilizer coefficients in Southern regions (i.e., regions 4, 5 and 6), are due to (1) currently low relative yields and (2) favorable soil and climatic conditions which result in a high response to fertilizer inputs.

Machinery coefficients, in 1954, were highest in the Southern Plains, amounting to 32 cents per $1 of feed grain output. This situation is partially explained by low acre yields. Too, substitution of machinery for labor occurs especially in the Southern Plains as a result of

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**TABLE 8. DIRECT DEPENDENCE OF LIVESTOCK PRODUCTION ON FEED SECTORS, BY REGIONS, 1954.**

<table>
<thead>
<tr>
<th>Region</th>
<th>0.2 Feed grains</th>
<th>0.4 Forage crops</th>
<th>Other crops*</th>
<th>0.13 Prepared feeds</th>
<th>Total feed inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>0.08651</td>
<td>0.04221</td>
<td>0.2513</td>
<td>0.5905</td>
<td></td>
</tr>
<tr>
<td>Corn Belt</td>
<td>0.34644</td>
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<td>0.3349</td>
<td></td>
</tr>
<tr>
<td>Lake</td>
<td>0.30270</td>
<td>0.16120</td>
<td>0.03321</td>
<td>0.07910</td>
<td></td>
</tr>
<tr>
<td>Appalachian</td>
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<td>0.03045</td>
<td>0.57311</td>
<td></td>
</tr>
<tr>
<td>Southeast</td>
<td>0.22272</td>
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<td>0.03165</td>
<td>0.20020</td>
<td></td>
</tr>
<tr>
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<td>0.19810</td>
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<td>0.03991</td>
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</tr>
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<td>0.02194</td>
<td>0.19918</td>
<td></td>
</tr>
<tr>
<td>N. Plains</td>
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<td>0.07716</td>
<td>0.02194</td>
<td>0.19918</td>
<td></td>
</tr>
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</tr>
<tr>
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<td>0.16046</td>
<td>0.04722</td>
<td>0.19631</td>
<td>0.48560</td>
<td></td>
</tr>
</tbody>
</table>

*Other crops include food grain (sector 0.3), vegetables and fruit (sector 0.5), oil crops (sector 0.6), and miscellaneous agriculture (sector 0.9).
favorable conditions such as level topography and large-scale operations. The machinery input coefficients for Southern regions (regions 4, 5 and 6) alone are somewhat misleading. Large sources of power are furnished by horses and mules (part of miscellaneous agriculture sector), which substitute for machinery. Considering both forms of power, the Appalachian region required 32 cents, the Southeast required 29 cents, and the Delta States required 35 cents per $1 of feed grain output. Horse and mule power is relatively minor outside the South.

Petroleum inputs were highly correlated with machinery inputs. Chemical inputs such as sprays, dusts and antifreeze, per dollar of feed grain output, were highest in Mountain and Pacific regions but relatively minor as compared with other industrial inputs.

**DIRECT INDUSTRIAL REQUIREMENTS PER DOLLAR OF FOOD GRAIN OUTPUT**

Industrial inputs per $1 of food grain output in the United States averaged 46 cents in 1954, compared with industrial inputs of 53 cents for feed grains. The difference results mainly because feed grains have lower per acre crop values, both in yield and crop price. Too, feed grains require, generally, more machinery inputs than food grains. Regional differential costs for growing food grains (mainly wheat, except in the Delta region where rice is the main food grain crop) are available in table B by summing, analogous to the procedure followed with feed grains, the respective columns 1.3, 2.3, 3.3, ..., 10.3 for rows 0.18, 0.19, 0.20, 0.21 and 0.22. The lowest industrial input was 38 cents per $1 of food grain output in the Pacific States (region 10). Above-average wheat yields per acre, together with low unit production costs on large-sized Oregon and Washington grain farms, cause this low unit industrial purchase. The Great Plains (regions 7 and 8) and the Mountain States had industrial inputs of 46 cents, while the Corn Belt had 52 cents per $1 of output. The Great Plains use less fertilizer per acre, and per dollar of food grain output, than does the Corn Belt. Also, large-scale operations in the Great Plains result in lower machinery costs per acre and per dollar of output than in the Corn Belt.

Fertilizer inputs per dollar of food grain output, in 1954, were generally lowest in the Great Plains areas and highest in the South. An exception was the Delta States with a fertilizer cost of 3 cents per $1 of feed grain output. However, most of the food grain output in the Delta Region was rice, a crop with high yields and value per acre.

**DIRECT INDUSTRIAL REQUIREMENTS PER DOLLAR OF FRUIT AND VEGETABLE OUTPUT**

The sum of industrial inputs per $1 of fruit and vegetable output was 27 cents for the United States in 1954. Regional differentials in industrial inputs can be determined, as with feed grain requirements, by summing entries in columns 1.5, 2.5, 3.5 . . . 10.5 for rows 0.18 through 0.22 in table B.

Regions 1, 5 and 10 produced 66 percent of the total United States fruit and vegetable output in 1954. The Northeast (region 1) purchased 37 cents of industrial inputs per dollar output of vegetables and fruit. In contrast, the Southeast (region 5) and Pacific States (region 10) used only 25 cents. Relatively high industrial inputs in the Northeast result from the high proportion of vegetable crops grown (e.g., potatoes, truck crops, etc.). As compared with fruits, truck crops generally require more fertilizer, machinery and petroleum products per unit of output. Because fruits and vegetables have high per acre values, industrial inputs per dollar of output were lower than for feed and food grains. As compared with the United States average of about 52 cents per $1 of feed grain output, and 47 cents per $1 of food grain output, each $1 of fruit and vegetable output used only 27 cents of industrial inputs. Fruit and vegetable production, however, requires relatively more labor than does grain production.

**DIRECT INDUSTRIAL REQUIREMENTS PER DOLLAR OF COTTON OUTPUT**

A dollar of cotton output in the United States required approximately 21 cents of industrial inputs such as fertilizer, chemicals, machinery, petroleum, etc. Regions 4, 5 and 6 used more fertilizer and machinery, per dollar of cotton output, than regions 9 and 10. Cotton production in the Mountain and Pacific states (regions 9 and 10) is concentrated mainly on large-scale farms with low per unit costs. The South (i.e., regions 4, 5 and 6) has small cotton farms with relatively large investments per acre. Too, yields are considerably lower in the South than in the irrigated western region.

**DIRECT INDUSTRIAL REQUIREMENTS PER DOLLAR OF TOBACCO OUTPUT**

Approximately 78 percent of the total tobacco output in 1954 was produced in the Appalachian region. Industrial inputs of 17 cents were required per $1 output of tobacco in region 4 (sum of coefficients in column 4.7 for rows 0.18, 0.19, 0.20, 0.21 and 0.22, table B). This coefficient is lower than for any other crop sector studied. Again, tobacco is a crop which yields a high value of output per acre and has relatively small machinery inputs, although fertilization rates are heavy. Like cotton, fruits and vegetables, tobacco has a large requirement for human labor (inputs from the household sector), whereas most of the planting and harvesting operations for grain are done mechanically.

**INTERDEPENDENCE BETWEEN SECTORS**

An examination of the flow table (table A) and the input-output coefficients (table B) indicates direct relationships between sectors of the economy. Interdependence coefficients (table C) express numerically the essential characteristic of the input-output system—the direct, indirect and circular tie-up between sectors within the economy. Stated more technically, interdependence...
coefficients summarize the combined direct and indirect requirements of all sectors resulting from the delivery to final demand of $1 of output from each sector.

That the indirect flows among agricultural regions and between agriculture and industry are more numerous and of greater complexity is evidenced from the greater number of nonzero coefficients in the interdependence matrix (table C) than in the matrix of input-output coefficients (table B). Out of a possible 10,609 cells in table B, there are 1,000 nonzero input-output coefficients reflecting the direct relationships between sectors. In table C, almost all cells have nonzero coefficients, illustrating explicitly the relationships which table B shows only implicitly—that the output of every sector is related in some manner to output of most other sectors in the economy.

Details on interdependence coefficients for the 103 sectors studied are provided in table C. This table is the inverse of the 103-order input-output matrix in table B.18 However, to present economic interdependence in a broader fashion, interdependence coefficients are discussed for somewhat fewer aggregations in this section. The interdependence coefficients to be discussed for broad summarization are derived from the inverse of the aggregated input-output tables presented in the previous section. Where discussion relates to smaller aggregation, its basis will be the coefficients from the 103-order inverse matrix of table C.

A TWO-SECTOR AGGREGATION

The economy is divided into two endogenous sectors, agriculture and industry. Households are considered to constitute an exogenous sector in an open model. Interdependence coefficients for this overly simplified model are presented in equation 6 and are repeated in table 9.

Table 9 shows that a $1 delivery of agricultural goods (unprocessed) to final demand required a gross output of $1.42 by agriculture and 80 cents by industry in 1954. Likewise the delivery of $1 of industry goods to final demand required directly and indirectly an output of 12 cents from agriculture and $1.82 from industry. These results suggest that the impact upon the total economy, in terms of dollars of total output generated, resulting from the delivery of $1 of agricultural products (unprocessed) to final demand was $2.22 (1.42 + .80 = 2.22). The delivery of $1 of industry products to final demand generated a total output of $1.94 (.12 + 1.82 = 1.94).

Coefficients in table 9 are related to deliveries to final demand rather than to total production within a sector. To derive the indirect and direct requirements per dollar of output or production, it is necessary to divide each column entry in the table of interdependence coefficients by the diagonal element of that particular column. Thus 56 cents (.80/1.42 = .56) of industry output was required directly and indirectly per $1 of agricultural production in 1954. Comparing direct requirements of 32 cents of agriculture from industry (table 2) with direct and indirect requirements of 56 cents indicated, by subtraction, that indirect requirements were 19 cents. Hence, $1 increase in agricultural output generated 32 cents, or 63 percent of industry output directly, while 19 cents, or 37 percent of industry output, was generated indirectly. For instance, increased agricultural output required additional fertilizer which required chemicals, etc.

Similarly, $1 of industry output required directly and indirectly 7 cents (.12/1.82 = .066) of gross output from agriculture. Direct requirements upon agriculture per $1 of industry output were 5 cents (table 2). Consequently, by subtraction, indirect requirement from agriculture generated by $1 of industry output was 2 cents or about 28 percent of total agriculture requirements.

Although sectors are highly aggregated, agriculture demonstrated relatively greater direct and indirect dependence upon industry than industry upon agriculture.

A FOUR-SECTOR AGGREGATION

Interdependence coefficients computed from the 4-order input-output matrix in table 6 are presented in table 10 and indicate some general interdependence relationships existing between agriculture and related segments of industry. A $1 delivery of agricultural processing goods (sector I) to final demand generated 60 cents of output in agriculture, $1.20 in agricultural processing industries and 69 cents (.23328 + .46012 = .69340) in industries II and III. A $1 increase in output of agricultural processing industries generated 50 cents (.60114/1.19910 = .5032) of agricultural output. Direct requirements from agriculture per $1 of agricultural processing output were 56 cents (table 6). Hence, 14 cents (.50 - .36 = .14) or 28 percent of agricultural output was generated from indirect or circular flows. For example, livestock products delivered to meat packing plants required internal flows of feed grains, forage, etc.

The delivery of $1 of agricultural goods (unprocessed) to final demand causes a corresponding increase in gross output of: 3.1 cents in agricultural processing industries; 36.6 cents in agricultural processing industries; 50.4

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18 More precisely, table C is the inverse of the matrix (I-A) where the matrix A is represented by table B.

TABLE 2. INTERDEPENDENCE COEFFICIENTS FOR A TWO-SECTOR MODEL OF THE UNITED STATES ECONOMY, 1954. (UNITS ARE DOLLARS)

<table>
<thead>
<tr>
<th></th>
<th>Agriculture</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1.42</td>
<td>0.12</td>
</tr>
<tr>
<td>Industry</td>
<td>0.80</td>
<td>1.82</td>
</tr>
</tbody>
</table>

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17 Each entry shows the amount that gross output of the sector named at the left would change, given a change of $1 in the final demand for products of the sector named at the top.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Includes ISC sectors 0.1 through 0.9.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector I includes ISC 0.10, 0.11, 0.12, 0.14 through 0.17.</td>
<td></td>
</tr>
<tr>
<td>Sector II includes ISC 0.13 through 0.20.</td>
<td></td>
</tr>
<tr>
<td>Sector III includes ISC 0.22.</td>
<td></td>
</tr>
</tbody>
</table>
Deliveries to final demand of agricultural products (in the ISC model) consist mainly of value of home consumption of farm products and inventory changes. Accordingly, it is more meaningful to discuss the direct and indirect effects on other sectors associated with changes in agricultural output, rather than the effects within agriculture itself.

An increase of $1 of agricultural output generates gross output of: 2.3 cents in agricultural processing industries; 36.3 cents in agricultural furnishing industries; and 36.2 cents in "all other" industries. Comparing these results, representing direct and indirect effects, with corresponding coefficients in table 6, representing only direct effects, indicates that a sizable amount of output is generated indirectly. For example, the direct requirement per $1 of agricultural output upon agricultural processing industries is 0.1 cent. Consequently, the corresponding indirect requirement upon the agricultural processing sector is $0.0260 - $0.00143 = $0.02117 cents. In other words, the direct dependence of agriculture upon agricultural processing industries is 0.1 cent. Likewise the corresponding indirect requirements upon agricultural furnishing industries are 7.6 cents (0.26319 - 0.18675 = 0.07644) or 29 percent of the total impact on processing industries and other sectors is greater. Consequently, indirect output in the Corn Belt, generated by a $1 increase in agricultural processing industry output, is 3.8 cents [$15/1.20 - 8.7 = 3.8]. For example, 3.8 cents or 50 percent of the induced Corn Belt output is associated with (1) shipments of feed grains to livestock sectors (outside the Corn Belt) that subsequently are purchased by processing industries and (2) shipments of feed grains to prepared feeds (ISC 0.13).

A gross output of 6.7 cents, 6.3 cents, 6.0 cents and 6.2 cents in the Lake States, Northeast, Northern Plains and Pacific States, respectively, is generated for each $1 of agricultural processing products delivered to final demand. The smallest induced output is 2.5 cents in the Delta States. In fact, $1 increase in demand for agricultural processing goods generates only 11.4 cents of gross output in the Southeastern section (regions 4, 5 and 6) of the United States. Correspondingly, a gross output of 20.5 cents is induced in the Western states (regions 7, 8, 9 and 10), while the quantity is 27.2 in the Northeastern section (regions 1, 2 and 3).

In contrast, change in final demand for industrial products (industry sectors II and III) has a smaller relative effect on production in agricultural regions.

A 13-SECTOR AGGREGATION

Interdependence coefficients computed from the 13-order input-output matrix of table 7 are included in table 11.

As stated previously, the total impact upon agriculture, associated with the delivery of $1 of agricultural processing products (sector I) outside the system, is 59.1 cents. Twenty-five percent, or 15.3 cents of the output generated in agriculture, occurs in the Corn Belt—more than twice that of any other region. Corresponding direct requirements of agricultural processing industries upon the Corn Belt are 8.7 cents (table 7). Consequently, indirect output in the Corn Belt, generated by a $1 increase in agricultural processing industry output, is 3.8 cents [$15/1.20 - 8.7 = 3.8]. For example, 3.8 cents or 50 percent of the induced Corn Belt output is associated with (1) shipments of feed grains to livestock sectors (outside the Corn Belt) that subsequently are purchased by processing industries and (2) shipments of feed grains to prepared feeds (ISC 0.13).

<table>
<thead>
<tr>
<th>Agricultural regions</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 North- east</td>
</tr>
<tr>
<td>1</td>
<td>1.29475</td>
</tr>
<tr>
<td>2</td>
<td>0.01938</td>
</tr>
<tr>
<td>3</td>
<td>0.05652</td>
</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>6</td>
<td>0.00207</td>
</tr>
<tr>
<td>7</td>
<td>0.00001</td>
</tr>
<tr>
<td>8</td>
<td>0.01201</td>
</tr>
<tr>
<td>9</td>
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<tr>
<td>10</td>
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<td>0.53243</td>
</tr>
<tr>
<td></td>
<td>0.56233</td>
</tr>
</tbody>
</table>

*Each entry shows the amount that the gross output of the sector named at the left would change, given a change of $1 in the final demand for products of the sector named at the top.

1 Consists of ISC Sectors 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17.

2 Consists of ISC Sectors 0.13, 0.18, 0.19, 0.20 and 0.21.

3 Consists of ISC Sector 0.22.

4 This figure (59.1 cents) is the sum of coefficients in column 1 for rows 1 through 10, table 11. The difference between the corresponding figure in table 10 relates to aggregation and rounding errors.

5 Livestock sectors, whose products flow to processing industries, purchase the prepared feed.
The direct and indirect relationships of regional agricultural production upon industries providing factor inputs are shown in rows II and III for columns 1 through 10 of Table 11. These results show that for each $1 of Northeast agricultural products delivered to final demand, output of 55.2 cents is generated in agricultural furnishing industries. Or, for each $1 of Northeast agricultural output (rather than deliveries to final demand) output of 13 cents \((0.43 - 0.30 = 0.13)\) is caused by indirect or circular flows.

As compared with the Northeast, the total impact upon agricultural furnishing industries associated with deliveries to final demand of other regions is small: A $1 increase in Corn Belt deliveries causes a 33.5-cent change in sector II output; a $1 change in Lake States deliveries to final demand causes a 37.5-cent change in sector II output. In general about 30 percent of the total impact upon industries, associated with changes in agricultural production, is caused by circular and indirect transactions.

**INTERDEPENDENCE AMONG AGRICULTURAL REGIONS**

An emphasis in this study is quantification of interdependence among regional economic sectors. This objective was accomplished only partially, since while agriculture is defined on a regional basis, industries are defined only on a national basis. Regional industrial requirements are not related to regional agricultural production and vice versa. Lack of adequate data necessitated these simplifications in empirical estimation of regional flows. Consequently, interdependence coefficients reflect numerical dependence of each region upon other regions only through agricultural sectors.

When data become more readily available, studies should be designed to define all sectors on a regional basis, providing a framework for quantifying “total” interdependence among regions.

In terms of the magnitude of interregional interdependence coefficients, the Northern Plains was most dependent upon other agricultural regions (Table 11). A $1 increase in Northern Plains agricultural products delivered to final demand generated 9.5 cents of agricultural output in other regions. Of this, the Mountain States accounted for 5.9 cents or 62 percent of the increase in output so generated. Each $1 of Northern Plains livestock products delivered outside the system generated in the Mountain States: 7.9 cents of livestock output and 2.3 cents of forage output (Table C).

Likewise, 1.5 cents of livestock in the Southern Plains was associated with each $1 of Northern Plains livestock products. Also a two-way dependence is shown between the Northern and Southern Plains. That is, the Southern Plains (region 7) required feed grains from the Northern Plains, while the Northern Plains purchased feeder animals from the Southern Plains. Similar comparison can be made between other regions.

Also, agriculture in the Southern Plains showed a high dependency upon other regions. A $1 delivery to final demand of livestock products in the Southern Plains required 2.7 cents from feed grains in the Northern Plains, 6.9 cents and 2.0 cents from livestock and forage, respectively, in the Mountain States. Tracing these individual flows back through the model indicates that an increase in output of feed grains (2.0 cents) in the Corn Belt (sector 2.1) consisted primarily of direct flows to livestock in the Southern Plains and indirect flows to prepared feeds (sector 0.13) that were purchased in region 7. Similarly, feed grains requirement in the Northern Plains (sector 8.2) is divided into direct and indirect flows. Purchases by the Southern Plains from the Mountain States (sector 9.1) were mainly feeder cattle and sheep. Increases in forage output in the Mountain States resulted from the increased requirements of feeder animals subsequently shipped to the Southern Plains.

Each $1 of agricultural products delivered to final demand from the Pacific States generated 8 cents of agricultural output in other regions. The largest tie-up is with agriculture in the Mountain States. For example, each $1 of livestock products (sector 10.1) delivered to final demand directly and indirectly, required 2.0 cents of feed grain output in the Corn Belt (sector 2.2), 2.5 cents of livestock output in the Southern Plains (sector 7.1), 7.2 cents of livestock output in the Mountain States (sector 9.1), and 2.0 cents of forage crop output in the Mountain States (sector 9.4). The induced output of 2.0 cents from feed grains in the Corn Belt consisted chiefly of direct feed grain shipments to prepared feeds (sector 0.13) which, in turn, were purchased for (a) livestock in region 10 and (b) feeder livestock raised in other regions and purchased in region 10.

Agriculture in the Southeastern section of the United States (regions 4, 5 and 6) also is dependent upon feed grain production in the Corn Belt. A $1 delivery of livestock products from the Appalachian region to final demand requires an increase in output of 3.9 cents of feed grains in the Corn Belt (sector 2.2). A $1 delivery of livestock products in the Southeast (sector 5.1) to final demand requires 2.0 cents of feed grains in the Corn Belt (sector 2.2). A $1 delivery of livestock in the Delta States (sector 6.1) requires 11.4 cents of feed grains in the Corn Belt (sector 2.2).

The Corn Belt has a relatively large dependence on livestock production in the Great Plains (regions 7 and 8) and Mountain States (region 9). One dollar of livestock products in the Corn Belt delivered to final demand required livestock output of 1.0 cent in the Southern Plains (sector 7.1), 3.8 cents from livestock in the Northern Plains (sector 8.1), and 1.4 cents from livestock in the Mountain States (sector 9.1).

**RELATION OF AGRICULTURAL PROCESSING SECTORS TO OTHER SECTORS**

The most important changes affecting farm sectors at present are those representing demand for agricultural processing goods (i.e., meat and poultry products, dairy products, grain products, etc.). Accordingly, the relationship between agricultural sector outputs and changes in final demand for selected agricultural processing sectors are discussed in the following section.

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22See ISC sectors 0.1 and 0.2 in Appendix A.
Final demand changes for meat and poultry products (sector 0.10). A $1 increase in demand for meat and poultry products (sector 0.10) generates, under the restrictions mentioned above, $1.09 of total gross output in agriculture and 73 cents in industries furnishing inputs to agriculture.\(^4\)

Great variation is evidenced in the gross output induced in different agricultural regions as the result of a one-dollar change in final demand for meat and poultry products. For example, 39.5 cents of output, or 35 percent of the total change of $1.09, is generated in the Corn Belt. In contrast, only 2.8 cents of gross output is generated in the Delta States. As previous knowledge suggests, the majority of the increase in gross output in each region, resulting from a one-dollar increase in consumption of meat and poultry products, is in livestock and feed crop sectors. Output generated in livestock and feed grain sectors of the Corn Belt (sectors 2.1 and 2.2) was 25.9 and 10.3 cents, respectively, as demand for meat and poultry products is increased by $1. Gross output of feed grains generated in the Corn Belt, required to produce the livestock generated in other regions, is greater than the total increase in livestock generated in all regions. Most Corn Belt feed grains are consumed by livestock within the region. However, the prepared feeds industry (sector 0.13) purchases large quantities of corn from the Corn Belt that subsequently flow to livestock in other regions. Too, the Corn Belt, a surplus feed grain region, makes direct shipments of corn to deficit feed grain regions.

Gross output generated in the Northern Plains, for each $1 of meat and poultry products delivered to final demand, was 14.7 cents, second only to the Corn Belt. Correspondingly, gross output induced was 11.4 cents in the Lake States and 8.8 cents in the Northeast. As a group, the Southeast regions of the United States (regions 4, 5 and 6) generated gross output of 14.6 cents for each additional dollar of meat and poultry products delivered to final demand. The parallel increase in agricultural output was 60 cents in the Northeastern regions (regions 1, 2 and 3), 21 cents in the Great Plains (regions 7 and 8) and 13 cents in the Western States (regions 9 and 10).

The effect of one dollar change in final demand for meat and poultry products on output in industrial sectors is shown in column 0.10 for the respective “furnishing” sectors of table C. The output generated in the machinery and related services sector (ISC 0.20) is 11.0 cents. Correspondingly, the gross output induced in the prepared feeds industry (sector 0.13) is 9.8 cents. The machinery sector has more of an indirect tie-up with consumption of meat products than the prepared feeds sector. The machinery sector provides inputs to feed grain sectors, which in turn provide inputs to livestock sectors. Also in terms of the model, the poultry processing plants purchase directly from livestock sectors, while prepared feeds are purchased directly by livestock sectors.

Output induced in the fertilizer industry, per $1 of meat and poultry products delivered to final demand, is 1.8 cents. Fertilizer use is associated with crop production, an indirect effect of the need of livestock for grains and forages. Hence, fertilizer production is indirectly related to demand for processed meat products.

Final demand changes for dairy products (sector 0.11). A $1 increase in demand for dairy products (sector 0.11) generates a total of 91.6 cents of gross output in agriculture and 67.7 cents of gross output in industries providing agricultural inputs.

The largest increase, or the greatest proportion of the 67.7 cents total, is generated in the dairy areas of the Lake States, Northeast and Corn Belt. The required increases in output, per $1 of dairy products delivered to final demand, are 19.3 cents in the Lake States, 18.7 cents in the Northeast and 18.3 cents in the Corn Belt. In the Northeast, 14.4 cents of the output is from the livestock sector and 1.8 cents from the feed grain sector. In contrast, 11.1 cents is from the feed grain sector and 5.1 cents is from the livestock sector in the Corn Belt. The increase of feed grains in the Corn Belt is entirely an indirect transaction. Feed grain flows to livestock sectors within and outside the regions and also to prepared feeds (sector 0.13). However, the majority of the increase in the livestock sectors of the Corn Belt is a direct transaction.

The Pacific States show the largest increase in gross output, of the Plains and Western states, associated with a one-dollar increase in final demand for dairy products. Most of the required increase (6.1 cents out of 8.3 cents) is in the livestock sector rather than in feed grains. This large proportion of the total in the region results because the region is a deficit producer of feed grains.

Gross output generated in industrial sectors, resulting from a one-dollar change in final demand for dairy products, was similar in magnitude to those required for changes in demand for meat and poultry products.

Final demand changes for processed grain products (sector 0.12). A $1-increase in the demand for processed grain products generated an increase in agricultural output totaling 57 cents and an increase in industry output totaling 98.2 cents.\(^5\) These magnitudes are in contrast to the effect on agricultural and industrial output when the changes in final demand were for meat, poultry and dairy products. A $1-increase in final demand for meat and poultry products requires an increase of $1.09 of agricultural output. The corresponding increase in final demand for grain products is only about one-half that generated by meat products. The differential is related primarily to the relative degree of processing that grain products undergo before reaching the final consumer. Accordingly, the increase in output associated with a one-dollar increase in final demand for grain products (sector 0.12) is larger than for the meat and poultry products (sector 0.10).

Among agricultural regions, the Great Plains (regions 7 and 8) show the greatest increase in gross output, an amount of 21 cents, given a change in demand of $1 for grain products. Other important effects are in the grain-producing regions of the Mountain States with an increase of 11.1 cents and the Corn Belt with an increase of 10.6 cents.

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\(^4\)The sum of the interdependence coefficients (table C) in column 0.10, rows 1.1 through 10.9, is 1.0900. Likewise, the sum of interdependence coefficients in column 0.19, rows 0.13, 0.18, 0.19, 0.20, 0.21 and 0.22, is .73300.

\(^5\)Excluding agricultural processing sectors.
Final demand changes for vegetable and fruit products (sector 0.15). The product mix of the vegetables and fruit sector includes highly processed products (e.g., canned and frozen foods) and vegetables and fruit with only minor processing. As stated earlier, the linear nature of the model assumes that this mix remains in a constant proportion for changes in demand.

A $1 increase in final demand for vegetable and fruit products required an increase in gross output of 54 cents from agriculture and a total of 70 cents from inconstant proportion for changes in demand.

Correspondingly, the largest regional increase in gross output was in the Pacific States with 19.6 cents or approximately 40 percent of the total increase in agricultural output. Other important effects were in the fruit and vegetable producing regions of the Southeast with an increase in gross output of 8.1 cents, and the Northeast with an increase of 8.0 cents. Relatively small coefficients (table C) relating final demand for vegetables and fruit to gross output of other agricultural sectors are evidenced.

Final demand changes for tobacco products (sector 0.16). A $1 change in final demand for tobacco products generates about a 50-cent increase in total agricultural output. The Appalachian region, the primary source of raw tobacco, accounts for 38.3 cents, or about 75 percent, of the gross output induced in agriculture resulting from the delivery of $1 of tobacco products to final demand. Similarly, gross output in the Southeast region was required to increase 6.6 cents.

Changes in final demand for agricultural furnishing industries have small effects on agricultural output. Approximately 10 percent of output from the agricultural furnishing industry was purchased by agriculture, while more than 40 percent was purchased by final demand sectors in the form of motor vehicles, fuel and oil, paints and varnishes, etc. The small valued coefficients in columns 0.18, 0.19, 0.20, 0.30 and rows 1.1 to 10.9 of table C are in line with the current structure of the United States economy. For example, changes in demand for lawn chairs and swimming pools are expected to have little effect on agricultural production.

Similarly, changes in final demand for sector 0.22 products show small effects on agricultural sectors.

PROJECTED INPUT-OUTPUT NEEDS

Input-output models have been used for projecting outputs in future time periods. The current model is used for projections of agricultural outputs in 1960 and 1975, based on derived structures in 1954. These projections have strict limitations because of the income elasticities of demand which attach to agricultural products and because of changing technical coefficients and factor substitution. They are based on demand projections from other studies. The section immediately following reviews procedures and assumptions used in making output projections.

PROCEDURES

Output projections for a particular time period require (1) an assumed final demand for particular sectors under consideration and (2) an inverse input-output matrix (a matrix of interdependence coefficients) which quantifies the functional relationship between final demand and gross output of each sector. Projections have been made for potential demands of farm products in future years by Daly (12) and Black and Bonnen (6). Black and Bonnen estimated the national total of domestic consumption and export for 1965. Daly projected future demands for farm products to 1960 and 1975.

In this study, projections of future demands for farm products were based primarily on those made by Daly. The important changes in final demand affecting agricultural sectors, for the input-output model in this study, were changes in demand for products of agricultural processing industries. That is, demand increases for agricultural products were reflected directly from householders to the industries which process farm products, then indirectly to agriculture. Agricultural processing industries (sectors 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17) were defined on a more aggregative basis in this study than the division of farm products used by Daly (12). Thus, it was necessary to build up estimates of future market requirements (final demand changes) for each processing sector used in this study. Individual product groups were weighted according to their relative share of output for respective sectors. Also, Daly based his 1975 projections on a population of 207 million; more recent estimates suggest a population of 228 million persons for 1975. Consequently, Daly's projections were adjusted upward by 10 percent for this study, to compensate for the revised population projections. Projected changes in final demand for the products of specified agricultural processing industries are given in table 12. These final demand projections serve as the basis for the projections in output which follow.

The assumptions made in projecting future demands for agricultural processing industries are, except for population, those of Daly (12, p. 74). Daly's assumptions

| TABLE 12. PROJECTED CHANGES IN FINAL DEMAND OF PROCESSING INDUSTRIES FOR 1960 AND 1975, UNITED STATES.* |
|-----------------|-------------------|-------------------|
| ISC sector      | 1954-60           | 1954-75           |
| 0.10 Meat and poultry products | 10               | 45                |
| 0.11 Dairy products            | 10               | 37                |
| 0.12 Grain products            | 0                | 5                 |
| 0.14 Miscellaneous food products | 10               | 40                |
| 0.15 Vegetable and fruit products | 15               | 45                |
| 0.16 Tobacco products          | 17               | 60                |
| 0.17 Textile products          | 18               | 45                |

*These quantities are the percentage increases in final demand for each group of products indicated at the left in table 12. The term final demand for processing sectors is used, since any increase in demand is reflected directly back to processing industries, and indirectly back to the relevant agricultural sectors.
are that (1) population will increase to about 207 million people by 1975; (2) growth in labor force and employment will parallel the growth in population; (3) world peace trends are expected, with a diminishing proportion of the nation's output devoted to defense; (4) productivity increases for the labor force will continue, comparable to the past and (5) prices for both agriculture and the economy as a whole are at 1953 levels. In addition, final demand for sectors other than agricultural processing industries are assumed fixed at the 1954 level. Consequently, estimated increases in output for each sector reflect only changes required to meet projected demands in the agricultural processing sectors.

Assumptions

Interdependence coefficients (table C) reflect changes in output of one sector associated with changes in final demand of other sectors. The basic assumptions underlying interdependence coefficients related to projective purposes are reviewed briefly.

Fixed and linear production coefficients specify that final demand deliveries will be forthcoming in the same mix as at the base period of the model, 1954, in this study. The implication of a fixed mix of final demand deliveries may be quite unrealistic, depending on the level of aggregation of sectors in the model and the nature of income elasticities of demand. For example, if all agricultural processing industries were aggregated into a single sector, projection of demand for "all agricultural processing goods" would suppose that relative consumption of individual products would remain in a constant proportion. However, an increase in final demand for agricultural processing goods is not likely to result exclusively from population increases, leaving the economy a blown-up model of today with respect to tastes, income and purchasing patterns. As is reflected by known coefficients of income elasticities, relative demand for farm products changes over time and with growth in national income.

For purposes of projection, seven individual agricultural processing sectors are identified (table 12). Although higher levels of aggregation alleviate the problem of fixed mix in final demand deliveries, they do not eliminate it. For instance, one of the agricultural processing sectors in this model is meat and poultry processing. Projections in demand for meat and poultry processing products, when all are aggregated into a single sector, imply that relative consumption of pork, beef, mutton and poultry remains in a constant proportion over time. Hence, the seriousness of a fixed mix of final demand deliveries for input-output projections is partly associated with the level of aggregation of sectors within the model.

Constant coefficients also imply that, for projected changes in final demand, output from producing sectors is available in the same ratios as during the base periods. This would mean, in agricultural production, that a constant comparative advantage exists among regions over time. Thus, any future shifts in cotton production, for example, from the Southeast to the Southwest are not indicated by the model. Or, future shifts of broiler production from the Northeast region to the Southeast region cannot be indicated by the model in its present form.

The assumption of a fixed mix of inputs has crucial implications on output projections for national agricultural furnishing sectors. Increases in agricultural production to meet projected final demand deliveries of agricultural processing industries require, according to the model, proportionate increases in land, labor, fertilizer, machinery, petroleum products, etc. However, land resources are limited and will not increase on a proportionate basis as agricultural production is expanded. Previous knowledge indicates that capital items, such as fertilizer, machinery and chemicals, substitute for land and for each other in the production of agricultural goods. Consequently, estimates of needed output in agricultural furnishing industries, to meet projected final demand deliveries of agricultural processing sectors, are understated by an input-output model used for projection purposes, except as requirement increases are offset by technical change.

Constant technology is implied when a model with fixed production coefficients is used. Hence, in this model, projections of future output must be based on 1954 production conditions. Generally, technological progress results in greater output with the same inputs or requires less inputs for the same or a greater output. Thus, restrictions of the model seemingly introduce opposing biases in the projection of output for future final demand conditions. The proportionality or fixed mix restriction causes an understatement of projected production in furnishing industries. On the other hand, the "constant technology" restriction may cause an overstatement of needed production.

Projections for 1960 and 1975

Projected demands for agricultural processing goods28 for 1960 indicate a required volume of farm output about 7 percent greater than in 1954 (table 13), and a required volume of industry output approximately 2 percent greater than in 1954.29 Similarly, projected demands for agricultural processing goods30 for 1975 could mean a volume of farm output about 28 percent greater than in 1954, and a required volume of industry output of approximately 6 percent greater than in 1954.29

As shown in table 13, production of livestock and livestock products must increase by 33 percent over the 1954 level to meet projected final demand for agricultural processing goods. The present model is not constructed to show relative increases in different types of livestock. However, in a study made by Barton and Rogers (4, p. 15), results indicated that relatively large production increases would occur with cattle, calves and poultry, while the lowest production increases would be evidenced with sheep and lambs. Additions to hog and milk production generally would be expected to equal the average increase for all livestock products. The fact that absolute increases needed in livestock production in 1975

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28See table 12 for projected changes in demand for agricultural processing industries.

29The change in output for industry is associated only with changes in demand for products of agricultural processing industries, holding final demand constant in other sectors.

30See table 12 for projected changes in demand for agricultural processing industries.
TABLE 13. CHANGES IN GROSS OUTPUT (WITH 1954 CONDITIONS) NEEDED TO MEET PROJECTED DELIVERIES TO FINAL DEMAND FOR PROCESSING INDUSTRIES IN 1960 AND 1975, UNITED STATES ECONOMY. (AGGREGATION OF COMMODITY GROUPS AND SUBDIVISIONS OF INDUSTRY)

<table>
<thead>
<tr>
<th>ISC sector</th>
<th>1954 to 1960</th>
<th>1954 to 1975</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute change</td>
<td>Percentage change</td>
</tr>
<tr>
<td>(Million dollars)</td>
<td>(Million dollars)</td>
<td></td>
</tr>
<tr>
<td>0.1 Livestock and livestock products</td>
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<tr>
<td>0.2 Feed grains</td>
<td>431.4</td>
<td>6.8</td>
</tr>
<tr>
<td>0.3 Food grains</td>
<td>69.4</td>
<td>2.8</td>
</tr>
<tr>
<td>0.4 Forage crops</td>
<td>190.9</td>
<td>7.6</td>
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<tr>
<td>0.5 Vegetable and fruit</td>
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<td>9.8</td>
</tr>
<tr>
<td>0.6 Cotton</td>
<td>101.9</td>
<td>3.0</td>
</tr>
<tr>
<td>0.7 Tobacco</td>
<td>171.5</td>
<td>15.0</td>
</tr>
<tr>
<td>0.8 Oil crops</td>
<td>24.2</td>
<td>2.2</td>
</tr>
<tr>
<td>0.9 Miscellaneous agriculture</td>
<td>91.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Total farm output</td>
<td>2,875.6</td>
<td>7.0</td>
</tr>
<tr>
<td>I Agr. proc. ind.*</td>
<td>5,430.4</td>
<td>8.5</td>
</tr>
<tr>
<td>II Agr. furnishing ind.</td>
<td>1,280.8</td>
<td>12.2</td>
</tr>
<tr>
<td>III All other ind.</td>
<td>3,174.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Total ind. output</td>
<td>9,685.5</td>
<td>1.8</td>
</tr>
</tbody>
</table>

* Agricultural processing industries include sectors 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17.

As indicated previously, the projected volume of industry output needed to meet 1975 demands for products of agricultural processing industries exceeded the 1954 output by about 6 percent. Agricultural furnishing industries would be required to increase output by slightly more than 5 percent, and "all other industries" would then be required to increase about 2 percent, in meeting an expansion in agricultural output to 1975 demand.

Of the agricultural furnishing industries indicated in table D, (sectors 0.13, 0.18, 0.19, 0.20 and 0.21), the largest percentage increase in output, about 30 percent, would be required in the prepared feeds industry (sector 0.13). Most of this increase is associated with projections in demand for livestock products (sectors 0.10 and 0.11). The second largest percentage increase in output, about 26 percent, indicated by the current input-output model is in the fertilizer industry (table D). Practically all of the fertilizer increases are indirect demands of livestock (sectors 0.10 and 0.11) processing sectors, which purchase livestock, but which, in turn, require crops which are fertilized. However, with the present rate at which new fertilizer practices are adopted, needed production increases in the fertilizer industry likely will be much greater than 26 percent.

The third largest projected increase, about 6 percent (table D), among the agricultural furnishing industries to meet 1975 demands on the agricultural processing industries is in the chemical industry (sector 0.19). As previous knowledge would suggest, almost half of this increase is related to projected demand for fruit and vegetable products (sector 0.15). "Indirect" inputs to farm fruit and vegetable sectors of fruit sprays and dust make up a large part of the increase.

The machinery and related services sector (0.20) showed a 3.7-percent increase in volume from 1954 to 1975; however, the absolute change was 1,368 million dollars (1954 dollars), the largest of any agricultural furnishing sector. An increase of 1.8 percent, or almost one-half of the total increase in sector 0.20, is related to increases in demand for meat and poultry products (sector 0.10).

Required increases in the petroleum industry (sector 0.21), i.e., gasoline, grease and oil, to meet 1975 final demand for agricultural processing products were 2.6 percent or 323 million dollars (1954 dollars). As in the machinery sector (0.20), a large part of the increase in production is related to projected changes in demand for meat and poultry products (sector 0.10).

In previous sections, discussion has centered around the needed output of all farm commodity groups and industrial sectors to supply final demand projections in 1975. Following is a discussion of the needed production job of regional product groups, to meet 1975 final demands for agricultural processing industries under 1954 production conditions.

Table D presents a summary of the effect upon gross output of all agriculture and industry sectors for projected changes, specified in table 12, in final demand for agricultural processing industries in 1960 and 1975.

REGIONAL OUTPUT REQUIRED FOR PROJECTED 1975 DEMAND

The projected demands for agricultural processing goods indicated a volume of farm output about 28 percent greater than in 1954. Table D shows the relative and absolute increases of each sector required to meet projected 1960 and 1975 demands. The Northeast region (region 1) is required to increase agricultural production 32.1 percent. Correspondingly, increases required by other regions are 30.4 percent for the Corn Belt, 30.8 percent for the Lake States, 31.3 percent for the Appalachians, 25.7 percent for the Southeast, 16.1 percent for the Delta States, 21 percent for the Southern
Plains, 28.4 percent for the Mountain States and 28.2 percent for the Pacific States. The smallest percentage increases were in the Delta States and Southern Plains regions where cotton production is relatively large. A large part of the cotton output flows to the CCC (part of final demand for sectors 6.6 and 7.6) and clothing and apparel industries (part of sector 0.22), which were not part of the 1975 projected final demands of processing industries.

In the Northeast region, an increase in agricultural production of 14.2 percent is related to projected changes in demand for meat and poultry products (sector 0.10); an increase of 11.6 percent is related to 1975 projected changes in demand for dairy products (sector 0.11).

For the Corn Belt, an increase of 22.8 percent of agricultural output is associated with 1975 projected changes in demand for meat and poultry products (sector 0.10), and 4.1 percent is associated with changes in demand for dairy products (sector 0.11). The large increase associated with processed meat products reflects the predominance of hogs and cattle in the Corn Belt.

The Lake States show an increase in agricultural production of 16.1 percent related to 1975 projected changes in final demand for meat and poultry products (sector 0.10).

The Appalachian region shows an increase of 11.3 percent in agricultural production associated with 1975 projected final demand for meat and poultry products (sector 0.10); a 3.9-percent increase related to 1975 projected demand for dairy products (sector 0.11). The large increase associated with processed meat products reflects the predominance of hogs and cattle in the Corn Belt.

The Southeast (region 5) shows an increase of 10.7 percent from 1954 associated with 1975 projected changes in final demand for meat and poultry products (sector 0.10); an increase of 6.4 percent related to projected demands for fruit and vegetable processed goods (sector 0.15); and a 3.1-percent increase in agricultural production related to projected demands for tobacco products (sector 0.16). Increases in farm output in the Delta region are more closely related to increases in 1975 final demand for livestock products (sectors 0.10 and 0.11) and textile products (sector 0.17). Likewise, increases in farm output in the Southern Plains are closely related to 1975 projected final demands for meat and poultry products (sector 0.10).

Increases in farm output (20.3 percent) in the Northern Plains also are responsive to 1975 projections in demand for meat and poultry products (sector 0.10). Food grain production for the Northern Plains shows a required increase in output of 1.6 percent as the result of 1975 projected deliveries to final demand of grain processing goods (sector 0.12). The Mountain States (region 9) show an increase in farm output of 19 percent related to 1975 demand for processed livestock products (sectors 0.10 and 0.11). Projected increases in demand for textile products (sector 0.17) in 1975 indicate an increase in agricultural production in region 9 of 2.4 percent—chiefly cotton and wool.

The greatest increases in agricultural production, 10.5 percent in the Pacific States, are associated with increases in demand for fruit and vegetable products in 1975. Daly (12, p. 82) indicates that consumption of fruits, primarily citrus fruits, may increase considerably more in the next two decades than vegetables. Thus, increases in fruit production in the Pacific States required to meet 1975 demand may be larger than indicated by the model.

APPENDIX A

DEVELOPMENT OF MODEL AND AGGREGATION OF DATA

The complexity of empirical problems in an input-output study cannot be fully appreciated without some firsthand experience in constructing a model and in deriving the data to be used in it. The number of possible separate entries or transactions in a flow matrix is approximately $n^2$, where $n$ is the number of individual sectors. Of course, the work load in estimations is considerably reduced when many of the entries are zero. In this study there are 10,609 or $(103)^2$ entries in the intermediate sectors and over 1,200 entries in final demand sectors. This combination requires estimating almost 12,000 possible flows. Fortunately, “only” about 1,500 entries are nonzero.

Most of the figures in the input-output table were obtained through indirect estimating procedures based on numerous data sources. Since no true figures were available, only by examining the estimating techniques and underlying assumptions, both implicit and explicit, can one attempt to judge the reliability of estimated flows in the matrix. Too, objectives, interests, available time and funds dictated the estimating tools used and the degree of precision accepted.

Production data for agriculture were in the most complete and usable form. Inputs to agriculture were less complete than production data but sufficient with minor conceptual adjustments. Main sources of data related to agriculture were available in Agricultural Statistics (72, 1955, 1956) with added detail provided in other United States Department of Agriculture publications.

Output of industry sectors was derived mainly from the Census of Manufactures (55). Most ISC industrial sectors were defined on a basis comparable to the Emergency Model classification (EM) of the 1947 Bureau of Labor Statistics input-output study (98). However, certain problems were encountered in projecting 1947 output calculations to 1954. That is, the Bureau of Labor Statistics had access to unpublished data sources, often confidential and security classified, that were not available for this study. Thus the assumption made here was that production in industries and portions of industries not covered by the Census of Manufactures would vary in the same rate from 1947 to 1954 as production in industries covered by the census. Fortunately, output of industries not covered by the census was relatively small.

Also, data needed for estimating interindustry flows, e.g., chemical industry inputs to grain processing, were

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8Sectors defined for this study are referred to as ISC sectors.
lacking in sufficient detail in most publications. Consequently, the transaction table of the 1947 interindustry study (102) was the basic industry reference for estimating some interindustry flows; this procedure used the comparable 1947 interindustry flow given in (102) as a base point to adjust for an estimate of the ISC 1954 transaction. It was assumed that the \( x_{ij} \), the flow of goods and services from industry \( i \) to industry \( j \), would vary in a direct proportion to the gross domestic output of industry \( j \). Essentially, this condition implies that a given product mix remains proportional over the period from 1947 to 1954.

The following discussion of individual sectors is not intended as a step-by-step account of all the estimating procedures, problems and data sources used for each sector. In fact, in some sectors many different approaches were attempted and discarded for various reasons. In most cases, explanations of individual sectors are in terms of output. In reality, estimates were made at times on both an input and output basis for purposes of checking. Further details of estimating procedures are available in (9b, p. 128).

### ISC 0.1 Livestock and Livestock Products

**Output**

Output of the livestock and livestock products sector is defined as follows:

**Meat animals.** Output of meat animals is cash receipts for cattle, calves, hogs, sheep, lambs and goats, plus value of home consumption and value of inventory change. Beginning farm inventory is compared with ending farm inventory in terms of numbers, and the difference (valued at the regional farm price) is used as value of inventory change.

**Poultry and eggs.** Output of poultry and eggs is cash receipts for broilers, chickens, eggs, turkeys and other poultry, plus value of home consumption and value of inventory change. Value of chicks hatched in commercial hatcheries also is considered part of production. An adjustment of 10 percent of farm receipts of chickens, turkeys, commercial broilers and eggs is added to output to account for nonfarm production.

**Farm dairy products.** Output of dairy products is cash receipts for fluid milk and cream, plus value of home consumption (both within the household and fed to calves). An adjustment of 2 percent of farm cash receipts for fluid milk and cream is added to output to account for nonfarm production.

**Other livestock and products.** Output of other livestock and products is cash receipts plus value of home consumption. Wool is the primary product.

**Main sources of data for estimating output of regional livestock sectors (ISC i.1, i=1, 2, 3 ... 10) were (62), (66), (69), (72, 1955), (76), (88), (89) and (94).**

**DISTRIBUTION**

The value of livestock (live) and unmanufactured wool and mohair was the source of exports and imports for the sector (81). Household purchases for each region include only the value of livestock products consumed on farms where grown. Intrasector flows for regional livestock sectors (ISC i.1, i=1, 2 ... 10) consist of (1) hatchery chicks and (2) milk fed to calves. Value of hatchery chicks purchased by farmers and value of milk consumed by calves on farms are available in (72, 1955). Value of farm manure, an intraregional flow from livestock sectors to crop sectors, is not considered in this study.

For the livestock sector, feeder animals were the only source of interregional transactions. Unfortunately, however, detailed data of origin and destination of feeder livestock were available only for California (8). To determine a rough flow pattern of feeder livestock for the United States economy in 1954, estimated least-cost flows (based on the transportation method solution) of feeder livestock were used, together with limited published feeder livestock transactions (8), some personal judgment and private consultation. Flow patterns were estimated in terms of numbers of feeder cattle and numbers of feeder lambs. Hence it was necessary to transform livestock numbers into dollars, the common denominator of the general model. For feeder livestock, regional prices were taken from the main livestock markets (86) and (87), and weighted by quantity sold in each market. Seven hundred pounds was approximately the average weight for feeder cattle, with 65 pounds as the approximate average weight for feeder lambs. The aggregated flow pattern (in dollars) for sheep and cattle is shown in the regional livestock sectors of table A.

Most intermediate sector purchases of livestock products by other sectors were obtained from data in (55) and (72, 1955). Some transactions were obtained by adjusting corresponding interindustry flows given in (102) by the 1954/1947 ratio of output of the receiving sectors. In some cases it was necessary to reconcile production statistics from agricultural publications with "cost of materials" data in the Census of Manufactures (55). Regional livestock transactions with industrial sectors were determined mainly on the basis of the relative share of livestock production in each region.

### ISC 0.2 Feed Grains

**Output**

The feed grain sector includes corn, barley, oats and sorghum grains.
Output of feed grains in value and physical units for the 10 agricultural regions is given in table 15. Physical production and unit prices for each of the products (corn, barley, oats and sorghum) are obtained from (91). Value of feed grain output for each region is physical production times regional unit price.

Physical quantities of on-farm inventory changes were obtained from (65, May 1956). Commodity Credit Corporation inventory changes were obtained from (50). "All other" inventories were obtained by subtracting CCC inventories from total off-farm stocks, given in (77, 1956). All physical inventory changes were obtained on a regional basis and were converted to value terms with appropriate regional prices. Purchases of feed grains by the household sector consisted mainly of home consumption of corn. These data by regions were available in (65).

Quantities of all feed grain crops consumed by livestock in each region were estimated by adjusting data given in (31) to a 1954 base. An additional small adjustment was made in the livestock consumption figure given in table 18, to permit balancing of total supply and distribution for each feed grain crop. A further assumption, in distributing each regional feed grain supply, was that livestock, household and seed requirements are met prior to industry requirements. Following the above procedure, regions 1, 4, 6, 7, 9 and 10 were deficit producers of corn, and regions 2 and 8 were surplus producers. Hence regions 2 and 8 supplied corn to livestock sectors in all deficit corn-producing regions on the basis of a least-cost transportation model. Groome (19) discusses the assumptions and procedure used in deriving a least-cost solution for corn shipments. The derived least-cost flow pattern is given in table 16.

The available supply of barley, oats and sorghum in each region was greater than consumption of these grains on farms in each region in 1954. Correspondingly, no interregional trade (as defined in this study) occurred with respect to these grains.

Quantities of feed grains purchased by individual industry sectors were obtained from (72, 1955) and (55).

Some adjustments were necessary to reconcile these two sources. Foreign trade data were given in (63, April 1956) and (61). Negligible information was available showing regional distribution of feed grains to industrial sectors. Consequently, the available regional supply, after fulfilling farm needs, was allocated to industrial sectors and foreign trade (export) on the basis of percentages expressing the relative consumption of the industrial sectors and the export sector. For example, if prepared feeds (sector 0.15) purchased 67 percent of the corn, and grain processing (sector 0.12) purchased 33 percent, the available supply of corn (minus what is used on the farm) in each region is distributed to these industries by the respective percentages. This procedure ignores differences in quality, transportation costs, etc.

### ISC 0.3 Food Grains Output

The food grain sector includes wheat, rye, rice and buckwheat. Output of food grains in value and physical units for the 10 agricultural regions is presented in table 17.

Physical production data in table 17 were obtained from (61) and (64). Regional unit prices for food grains were applied to physical production units to obtain value of output in each region.

Foreign trade data for food grains were obtained from (68, p. 18) and reconciled with (81) with minor adjustments. On-farm inventory changes were given in

### Table 15. Production of Feed Grains by Agricultural Regions, 1954*

<table>
<thead>
<tr>
<th>Agricultural regions</th>
<th>Feed grains</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Northeast</td>
<td>Corn Belt</td>
<td>Lake States</td>
<td>Appalachian</td>
<td>Southeast</td>
</tr>
<tr>
<td>Bu. dollars</td>
<td>Bu. dollars</td>
<td>Bu. dollars</td>
<td>Bu. dollars</td>
<td>Bu. dollars</td>
<td>Bu. dollars</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>141.2</td>
<td>221.8</td>
<td>1670.2</td>
<td>2401.7</td>
<td>496.4</td>
<td>650.7</td>
</tr>
<tr>
<td>Barley</td>
<td>15.7</td>
<td>13.8</td>
<td>16.3</td>
<td>12.5</td>
<td>34.9</td>
<td>30.2</td>
</tr>
<tr>
<td>Oats</td>
<td>166.2</td>
<td>34.7</td>
<td>515.6</td>
<td>356.7</td>
<td>352.8</td>
<td>244.8</td>
</tr>
<tr>
<td>Sorghum grain</td>
<td></td>
<td></td>
<td>1.0</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>293.3</td>
<td></td>
<td>2777.0</td>
<td>943.7</td>
<td></td>
<td>388.2</td>
</tr>
</tbody>
</table>

### Table 16. Flow Pattern of Corn From Surplus Corn-Producing Regions to Livestock Sectors in Deficit Corn-Producing Regions, Based on "Transportation Model" Solution, (1,000 Bushels)

<table>
<thead>
<tr>
<th>Surplus regions</th>
<th>Deficit regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8,259</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

*For all agricultural sectors, an October 1953 to October 1954 year was used. Hence, a 1953 crop year was used for corn and a 1954 crop year for barley, oats and sorghum grain.
Food grains fed to livestock were derived by adjusting estimates in \( (31) \) by the 1953-54/1949-50 ratio of units of livestock. Additional small adjustments were necessary in the livestock consumption figure to permit balancing of supply and distribution in the food grain sector. Food grains used for seed were available in \( (72, 1955) \). Purchases of food grains by industrial sectors were obtained from \( (55) \) and \( (72) \).

As with feed grains, published information indicating regional distribution of food grains to industrial sectors and foreign trade (export) was inadequate. Hence, available supply of food grains in each region was, after fulfilling farm needs, allocated to industrial sectors and foreign trade on the basis of percentages expressing the relative consumption of food grains by each of these sectors.

ISC 0.4 Forage Crops

The forage crop sector includes legume and grass seeds, hay and pasture. Since the majority of the forage produced is fed directly to livestock and consequently never enters the marketing system, the resulting pricing problem is difficult. A similar problem exists for feed grains but to a lesser degree. Initially, an attempt was made to estimate the supply and demand of forage feed units in each region, similar to the procedure followed by Jennings \( (31 \text{ and } 32) \). Reducing feed units to hay equivalent tons, pricing hay at the regional market price, yielded a total forage value of 4,035 million dollars. Estimated inputs (e.g., fertilizer, seed, labor services, land rental, machinery services, etc.) were valued at 2,494 million dollars, approximately 60 percent of the estimated forage output. Considering that forage is consumed primarily by livestock, the high estimated value for forage resulted in an input-output ratio for the livestock sector greatly exceeding 1.0. Therefore, any reduction in the value of forage output resulted in greater input-output balance for both the forage crops and livestock sectors.

Accordingly, the procedure followed in this study was to value forage output on the basis of inputs purchased by the forage crops sector. Experience with various data sources indicates that output statistics are more firm than input statistics. However, forage crops statistics were an exception.

ISC 0.5 Vegetables and Fruit

Purchases by nonlivestock sectors consisted largely of legume and grass seed. Physical quantities of seeds were obtained from \( (72, 1956) \) and seed prices from \( (77) \). Seeds rarely sold were valued at prices of similar seeds. Import and export data for seeds were obtained from \( (81) \). Winter cover crop seeds in each region were distributed to feed grains (ISC 0.2) and food grains (ISC 0.3) on the basis of the relative planted acres of feed and food grains. Forage crops purchased by the livestock sectors in each region were estimated as a residual figure after accounting for other transactions.
Production data in table 18 include both major and minor commercial vegetable and fruit areas (3).

DISTRIBUTION

From a marketing standpoint, vegetables and fruit reach the consumer through two distinct channels. Farmers sell fresh vegetables and fruit which enter wholesale and retail outlets and terminate with the consumer. Also, a certain amount of vegetables and fruit is sold to firms for processing, then shipped through trade channels to the consumer. In the 1947 Bureau of Labor Statistics input-output model (98), both of the above channels were used in distributing vegetable and fruit products. In this study regional output of vegetables and fruit was allocated to a single firm, namely vegetable and fruit processing (ISC 0.14). Procedure for distributing regional supplies to household sectors from secondary data sources was avoided. Vegetables obtained from farm gardens and home-grown fruit were purchases from the household sector. Relatively small amounts of sector 0.5 products were consumed by livestock sectors.

ISC 0.6 COTTON

OUTPUT

The cotton sector for each region includes both cotton lint and cottonseed. Value of output in each region was obtained from physical products data (56) and (92) converted to value terms using regional prices.

DISTRIBUTION

Foreign trade data for row cotton were obtained from (81). The Commodity Credit Corporation made additions to inventory for cotton (42) and (56). Cotton not exported or placed in inventory was allocated to textile products (ISC 0.17). Distribution of regional supplies of cotton to export and tobacco manufacturing (ISC 0.16). Regional distribution of tobacco, consistent with national totals was based on percentages expressing the relative purchases of export and tobacco manufacturing (ISC 0.16).

ISC 0.8 OIL CROPS

OUTPUT

Products of the oil crop sector are soybeans, peanuts, flaxseed and tung nuts. Physical production applied to regional unit prices yielded value of output (63) and (72, 1955). Output of the oil crops sector by regions is given in table 19.

DISTRIBUTION

Foreign trade statistics on oil crops were obtained from (81). On-farm inventory changes by regions were given in (77, 1955). Inventory depletions for CCC by regions were obtained from (50). “All other” inventory depletions were derived by subtracting CCC inventories from total inventory changes given in (72, 1955). The total quantity of unmanufactured tobacco not exported or placed in inventory was allocated to tobacco manufacturing (ISC 0.16). Regional distribution of tobacco, consistent with national totals was based on percentages expressing the relative purchases of export and tobacco manufacturing (ISC 0.16).
used for cotton and tobacco. Main sources of data for allocating oil crops were available in (55) and (72, 1955).

ISC 0.9 Miscellaneous Agriculture composition

The miscellaneous agriculture sector is an aggregation of miscellaneous crops and services as follows:
1. Sugar crops
   a. Sugar beets
   b. Sugar cane sirup
   c. Sorghum sirup
   d. Maple products
2. Miscellaneous crops
   a. Hops
   b. Broomcorn
   c. Cowpeas
   d. Velvet beans
   e. Popcorn
   f. Peppermint
   g. Spearmint
3. Forest, nursery and greenhouse products
4. Horses and mules services
5. Agricultural services
   a. Dairy services
   b. Farm management services
   c. Hay-baling
   d. Services for feed and food grains
   e. Cotton ginning
   f. Shearing sheep and goats and other services

OUTPUT AND DISTRIBUTION

Gross domestic output for ISC 0.9 is given in table 20.

Domestic production data for sugar crops, both quantity and value, were given in (64). The majority of sugar products were allocated to miscellaneous food processing (ISC 0.14) except for 3.5 million dollars consumed by the household sector. Output data on miscellaneous crops were allocated to miscellaneous food processing.

Forestry and nursery products data were available by states in (52). A major portion of the forest products were allocated to lumber and pulp mills (part of "all other industries"). Nursery and greenhouse products were purchased primarily by the household sector.

Estimating procedures for measuring the amount of power or services provided by horses and mules are rather arbitrary. The assumption was made that value of current inputs to horses and mules was equal in value to the power which they furnished. Primary inputs for horses and mules were feed grains and forage crops. Other inputs were veterinary supplies and services, housing, labor services, etc. Allocation of horse and mule services to farm sectors within the region was based on percentages showing relative tractor hours required by each commodity sector (9b, p. 245).

Value of agricultural services was obtained from (52) and (53, pp. 24, 26). If feasible, agricultural services were allocated to the closely associated crop or product; e.g., dairy services, shearing sheep and goats were allocated to the livestock sector, hay baling to the forage sector, etc. Farm management services were allocated to agricultural sectors according to the relative portion of cost receipts associated with each sector.

AGRICULTURAL PROCESSING INDUSTRIES

Agricultural processing industries—i.e., ISC 0.10, 0.11, 0.12, 0.14, 0.15, 0.16 and 0.17—are generally defined in terms comparable to the Emergency Model (EM) classification of the 1947 Bureau of Labor Statistics input-output model (98). Some of the differences and similarities in definition of the ISC sectors and the EM sectors are noted below.

ISC 0.10 MEAT AND POULTRY PROCESSING

The meat and poultry processing sector consists of three main products:
1. Meat packing and prepared meats
2. Products from poultry dressing plants
3. Poultry products with minor processing.

The first two categories listed above are comparable to census industries 2011, 2013 and 2015 plus an adjustment to include livestock slaughter by wholesale and retail trade. Also, sector EM-21 in the 1947 Bureau of Labor Statistics 192-sector classification (98, p. 49) is almost identical to the first two categories listed above. The third category includes slaughtering and handling of poultry products by wholesalers and retailers. Essentially, products of (2) and (3) above ultimately reach the consumer in the same condition but travel in two separate channels, one through large processing plants and the other to small retailers, restaurants and other similar outlets. Because of the difficulty in tracing out separate flow patterns with secondary data sources, we grouped (2) and (3) together rather than trace separate channels of distribution.

ISC 0.11 DAIRY PRODUCTS

The dairy products sector consists of the following main products:
1. Creamery butter
2. Natural cheese
3. Concentrated milk
4. Ice cream and ices
5. Special dairy products
6. Fluid milk and other products.

ISC 0.11 is comparable to census industries 2021-2027. It differs from EM-22 (98, p. 50) in that ISC 0.11 includes all fluid milk and cream. In the 1947 inter-industry study, fluid milk which is pasteurized and bottled was assumed unprocessed, in the manufacturing sense. In that framework, milk sold by farmers or dairy plants for eventual household consumption as fluid milk

<table>
<thead>
<tr>
<th>TABLE 20. GROSS OUTPUT FOR MISCELLANEOUS AGRICULTURE, 1954. (MILLIONS OF DOLLARS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous agriculture</td>
</tr>
<tr>
<td>Sugar crops</td>
</tr>
<tr>
<td>Miscellaneous crops</td>
</tr>
<tr>
<td>Forest, nursery and greenhouse products</td>
</tr>
<tr>
<td>Horses and mules services</td>
</tr>
<tr>
<td>Agricultural services</td>
</tr>
</tbody>
</table>
or cream was allocated directly to households. In this
study all farm milk products not consumed on the farm
were allocated to ISC 0.11. Allocating all dairy products
to ISC 0.11 avoided the necessity of adjusting cost struc­
tures of combination plants (selling both fluid milk and
manufactured products). In addition, this procedure
circumvented the need for establishing interregional
shipment patterns of farm dairy products (part of i.l,
i = 1, 2 ... 10) to household sectors.

ISC 0.12 GRAIN PROCESSING

The grain-processing sector consists of the following
main products:
1. Flour and meal
2. Cereal preparation
3. Rice cleaning
4. Blended and prepared flour.

The grain-processing sector is comparable to census
industries 2041, 2043-2045 (55). Grain mill processing
in this study was considered as two separate sectors,
rather than a single sector as in the Bureau of Labor
Statistics 1947 input-output study (98, p. 51). The di­
vision was made on the basis of consumption of grain
products—human and animal. The grain-processing
sector (ISC 0.12) purchases, among other inputs, grain
chiefly for processing and eventual sale as human food—
e.g., flour, breakfast cereal, etc.

ISC 0.14 MISCELLANEOUS FOOD PROCESSING

The following primary products are included in the
miscellaneous food-processing sector.
1. Miscellaneous food preparations
2. Beverages
3. Bakery and related products

The miscellaneous food-processing sector is compar­
able to EM sectors 25, 26, 27 and 28 given in (98, p.
51-52).

ISC 0.15 VEGETABLE AND FRUIT PROCESSING

Included in vegetable and fruit processing are the
following primary products:
1. Canned sea food
2. Cured fish
3. Canning and preserving food
4. Dehydrated fruit and vegetables
5. Pickles and sauce
6. Packaged sea food
7. Frozen fruit and vegetables
8. Fresh vegetables and fruit with minor processing.

Vegetable and fruit processing is comparable to EM-
23 in (98, p. 50) excluding fresh vegetables and fruit.
The logic for channeling fresh vegetables and fruit
through ISC 0.15 rather than shipping them directly
from farm sectors to household is discussed in reference
to the farm vegetable and fruit sector (ISC 0.5).

ISC 0.16 TOBACCO MANUFACTURING

Primary products of the tobacco manufacturing sector
are:
1. Cigarettes
2. Cigars
3. Chewing and smoking tobacco
4. Tobacco stemming and redrying.

The tobacco manufacturing sector is comparable to
sector EM-29 given in (98, p. 54).

ISC 0.17 TEXTILE PRODUCTS

Primary products in textile products are:
1. Woolen and worsted manufacturing
2. Cotton and rayon textiles
3. Carpet, rugs and miscellaneous textile goods.

The textile products sector is comparable to EM sec­
tors 30, 31 and 32 in (98, p. 53-56).

DISTRIBUTION OF AGRICULTURAL PROCESSING PRODUCTS

Primarily, agricultural processing products were allo­
cated to (1) other processing sectors and (2) final de­
mand sectors; e.g., export, government and household.
No “sales” were made to agricultural sectors with the
exception of burlap sacks and twine produced by textile
products (ISC 0.17).

Interindustry transactions were derived in part from
(55) and by projecting corresponding interindustry flows
in (102) by the 1954/1947 ratio of gross domestic out­
put of the respective purchasing industries.

Transactions with foreign trade are available in (81)
and (51, 1955). Adjustments necessary to convert (1)
imports from a foreign port value to landed value and
(2) export values to producer’s values are discussed in
the foreign trade section. Purchases of government from
individual processing sectors were estimated by adjust­
ing corresponding transactions in (102) for 1954/1947
ratio of (1) military consumption of appropriate prod­
ucts and (2) wholesale price index. Inventory changes
of finished products were obtained from (55).

AGRICULTURAL FURNISHING INDUSTRIES

Agricultural furnishing industries, i.e., ISC 0.13, 0.18,
0.19, 0.20 and 0.21, are likewise defined in terms com­
parable to the Emergency Model (EM) classification
of the 1947 Bureau of Labor Statistics input-output
model (98). The allocation of products from the fur­
nishing industries to agricultural sectors required some
special estimating procedures. The major problems with
each sector are summarized as follows:

ISC 0.13 PREPARED FEEDS

The prepared feed sector is comparable to the animal
feeds component of EM-23 (98) and census industry
2042 (55).

Total livestock consumption of commercial feeds was
valued at 2,584 million dollars (producer’s value) as
estimated from data in (55) and miscellaneous agricul­
tural publications. Distribution of prepared feeds to
regional livestock sectors and to horses and mules (part
of miscellaneous agriculture, in each region) was based
primarily on Jennings’ livestock consumption data (31)
and (32). Relative livestock consumption of commercial
feeds in each region was projected to 1954 by the 1954/1949 ratio of grain-consuming livestock.

ISC 0.18 FERTILIZERS

The fertilizer manufacturing sector is almost identical to EM-58 (98, p. 60). Crop sectors purchased the largest portion of fertilizer output. Pounds of nitrogen, phosphorus and potash applied in 1954, by regional commodity groups, were obtained from (80). Physical quantities of fertilizer nutrients used by farmers were converted to purchaser's value with prices received from Ibach (26). A margin of 0.70 was used to convert purchaser's value to producer's value. This percentage was obtained from (99, p. B-19) and modified to reconcile portion of fertilizer output. Pounds of nitrogen, phosphorus and potash applied in 1954, by regional commodity groups, were obtained from (80). Physical quantities of fertilizer nutrients used by farmers were converted to purchaser's value with prices received from Ibach (26). A margin of 0.70 was used to convert purchaser's value to producer's value. This percentage was obtained from (99, p. B-19) and modified to reconcile purchaser's value (computed from the above method) and output figures in (55).

ISC 0.19 CHEMICAL PRODUCTS

The chemical products sector is comparable to EM sectors 48-57 and 59-61 in (98).

Three main chemical sector products purchased directly by agriculture are: (1) spray and dust materials, (2) veterinary supplies and (3) antifreeze.

Average per acre costs of spray and dust materials for each regional product sector were derived from (7). Percentage of acres treated was assumed to remain constant from 1952 to 1954. Cost of spray material on weeds in fence rows, etc., was allocated to commodity groups on a relative acre basis (e.g., if 20 percent of the cropland was planted to feed grains in a particular region, 20 percent of the spray material used on weeds was absorbed by the feed grain sector). Cost of spray materials for livestock and barns available in (7) by states was likewise adjusted to a 1954 base by the prices-paid index for supplies.

Purchaser's value of spray and dust material (180.17 million dollars) was converted to producer's value (144.14 million dollars) with the margin given in (99, p. B-11).

Purchaser's value of veterinary supplies, 96.49 million dollars by states for agriculture, was available in (79, p. 5), and converted to producer's value, 44.19 million dollars, with the margin given in (99, p. B-13).

Value of antifreeze purchased by farmers was given in (52, p. 11). Farm consumption of antifreeze in 1955 (base year of data in 52) was assumed not to differ significantly from 1954. Antifreeze was allocated to national commodity groups according to percentages given in (99, p. B-37). Allocation of antifreeze to commodity groups within regions was based on relative acres for crop sectors and relative numbers of grain-consuming livestock for livestock sectors. Purchaser's value of antifreeze consumed within agriculture was converted to producer's value with a margin of 50 percent, given in (99, p. B-12).

isc 0.20 MACHINERY AND RELATED SERVICES

The machinery and related services sector is comparable to EM sectors 65, 104, 112, 113, 145, 188 and 189 given in (98, p. 65 ff). ISC 0.20 transactions with agriculture are tractor and farm machinery use, truck use and automobile use (farm share). Each is discussed separately.

Tractor and farm machinery use. Tractor and farm machinery use in agriculture was measured by:
1. Labor for repair of farm machinery and tractors.
2. Producer's value of repair parts for machinery and tractors.
3. Depreciation of tractors and machinery.

Value of labor services for repair of farm machinery was 147 million dollars, as given in (79, p. 9). These 147 million dollars were distributed to regions proportionate to purchased repair parts and tires for farm machinery, presented by states in (79, p. 3). Value of labor services for repair of tractors, likewise given in (79, p. 9), was distributed regionally in proportion to purchased repair parts for tractors. Purchaser's value of repair parts for tractors and other machinery was converted to producer's value with a margin of 0.60 derived from (99, p. B-21). Depreciation of tractors and other farm machinery by states, and hence by regions, was available in (62, p. 57).

Regional totals of tractor repairs, depreciation and services were allocated to commodity groups within regions on the basis of percentages expressing the relative number of tractor hours required for each commodity sector (9b, table 90).

Truck use. Truck use in agriculture was measured by:
1. Labor services for farm trucks.
2. Producer's value of repair parts for farm trucks.
3. Depreciation on farm trucks.

These three components were estimated from the same general sources as tractor and machinery inputs. Estimated value of truck use (regional totals) was distributed to commodity sectors within regions according to percentages expressing the relative number of truck hours required for each commodity sector (9b, table 89).

Automobile use. Automobile use in agriculture was measured by:
1. Labor services for farm share of automobile.
2. Producer's value of repair parts for farm share of automobile.
3. Depreciation of farm share of automobile.

General sources and methods for estimating value of automobile use were the same as for tractors and machinery. Regional totals representing automobile use were allocated to commodity groups within regions according to percentages expressing the relative number of automobile hours required for each commodity sector (9b, table 90a).

ISC 0.21 PETROLEUM PRODUCTS

The petroleum sector is comparable to EM-62 in (98, p. 61).

Agricultural sector purchases of petroleum products, e.g., gasoline, oil and grease, were available (by states)
in (79, p. 3). Purchaser’s value was converted to producer’s value with a margin of 0.48 obtained from (98, p. B-17). Estimated producer’s value of petroleum products was separated according to farmer use—i.e., tractors, trucks, automobiles and stationary motors—and allocated to commodity sectors as discussed with ISC 0.20.

**ISC 0.22 All Other Industries**

This sector constitutes the largest segment of manufacturing and production of services in the economy. Transactions or flows to agriculture of ISC 0.22 products were margins associated with purchased inputs, miscellaneous farm expenditures and farm nonresidential rents.

**Margins associated with purchased inputs.** Input margins are the difference between purchaser’s value and producer’s value. Margins are chiefly wholesale and retail charges and transportation costs. Margins computed for all agricultural sector purchases were allocated among agricultural commodity groups in the same proportion as were the original purchases.

**Other farm expenditures.** All farm expenditure items not considered as primary products of other agricultural furnishing sectors or autonomous inputs (e.g., interest and labor charges) were included. Purchaser’s value of miscellaneous expense item was used, rather than producer’s value, because ISC 0.22 is an aggregation of the primary industries producing these items and the “service” sectors associated with input margins. For example, a shovel has a producer’s value of $1.00, wholesale margin of $0.10, retail margin of $0.15, transportation costs of $0.02, and hence a purchaser’s value of $1.27. The transaction between ISC 0.22 and agriculture is $1.27, the purchaser’s value, since ISC 0.22 is an aggregate sector of these individual industries. Miscellaneous farm expenditure items are:

1. Repair and operation of capital items
2. Miscellaneous hardware
3. Small hand tools
4. Containers
5. Dairy supplies
6. Harness and saddlery
7. Fire, wind and crop hail insurance
8. Veterinarian fees (excluding supplies)
9. Electricity
10. Telephone
11. Lime.

Purchaser’s value of the above expense items was available in (79, pp. 4-5) by states and, hence, by regions. Veterinarian fees were distributed to regional livestock sectors and miscellaneous agriculture sectors (horses and mules) proportionate to the respective purchases of veterinary supplies. Dairy supplies were allocated directly to livestock sectors. Harness and saddlery were allocated directly to miscellaneous agriculture sectors (horses and mules). Lime was distributed to crop commodity sectors within regions proportionate to fertilizer purchases. The remaining expense items were distributed to commodity sectors within each region according to percentages expressing the relative share of cash receipts of commodity sectors.

**Farm nonresidential rents.** Rental of farm service buildings and farm land was measured in terms of the estimated share of contract rent paid which relates to their use. Gross rent due landlords was 3,073 million dollars, given in (72, 1956). Imputed rent from dwellings was estimated at 683 million dollars, and government payments to landlords were 46 million dollars. Subtracting rent for dwellings and government payments from gross rent resulted in 2,343 million dollars. This total was distributed among commodity sectors within regions.

**ISC 0.23, 0.24 Foreign Trade**

Foreign trade is customarily treated as an exogenous sector. Exports are considered as its inputs and imports as its outputs. In the 1947 interindustry study (100), imports are divided into competitive and noncompetitive categories depending on whether the imported commodity or service is highly substitutable for a product or service produced in the United States. Since this study was based principally on secondary data, it was difficult to classify imports in this way. It was assumed that every import product is substitutable for some domestic product and hence all imports were treated as competitive. Imports were distributed to the corresponding sectors as if they were second products of the industry (foreign trade) and were channeled to the industries for which the products are primary.

**THE ADJUSTMENT OF FOREIGN TRADE VALUES**

Since the recorded export value is purchaser’s value and the import value is foreign port value, both needed adjustment for a producer’s value concept. Export value of commodities was adjusted to producer’s value by subtracting wholesale margins and transportation costs. Estimation of wholesale margins was obtained by the following computation:

Wholesale margin (percentage) = (percentage share of wholesale margin in the BLS 1947 study) \times (price index ratio of 1954/1947).

The percentage share of wholesale margins and price index ratios were obtained from (100, table 2) and (51, 1955, pp. 314, 327), respectively.

The same procedure was applied to transportation costs but with the freight index. For those sectors where specific freight indexes were not available, the combined index of agricultural goods and the consumer’s price index of transportation was used.

Import statistics for the United States are on the basis of foreign port value. The adjustment of foreign port value to landed value for imports was obtained by using the ratio of landed value to foreign port value given in the 1947 study (100). For the nine agricultural sectors, relevant ratios were calculated necessary for adjustment in import values; however, for the remaining industrial sectors an over-all average adjustment ratio of 0.17 was used.

**The appendix of (99) cites percentages for distributing gross rent on a "national" commodity basis. These percentages were adjusted to a regional commodity basis according to (1) relative acres of cropland for crop commodity groups and (2) relative numbers of livestock for the livestock sectors.

Imports and exports relating to government and household did not, however, need adjustment.
Foreign imports and exports of the 10 agricultural regions were assumed proportionate to value of related production in each region. This procedure was followed because most products lose their identity in transit, making it almost impossible with secondary data sources to associate individual products with points of origin and destination. Too, regional foreign trade is relatively small compared with regional output.

**ISC 0.25 Government gross output**

Total receipts on current account were defined as the gross output of government (federal, state and local). Total receipts, presented in table 21, were estimated following the procedure outlined in the appendix of (101) and data given in (95) and (97).

In the Bureau of Labor Statistics input-output study of 1947 (101), tax revenues covering all forms of revenues, i.e., sales, excise, license, income, etc., were usually classified according to the industry making the payment. No attempt was made to duplicate this painstaking effort for this study. Rather, the procedure for the intermediate sectors was to use the same proportion of revenue to the total government revenue paid by each industry in 1947. For example, in (102) government revenue from the chemical sector was 743.5 million dollars or 1.17 percent of total government receipts. One and seventeen hundredths percent of 99,828 million dollars (government receipts for 1954) is 1,167.99 million dollars, the flow from ISC 0.25 to ISC 0.19. Estimated revenues from national commodity groups in agriculture (e.g., ISC 0.1, 0.2) were further subdivided into regional commodity groups (e.g., ISC 1.1) on the basis of relative cash receipts.

Government flows to export consist mainly of purchases from U.S. government and government surplus sales. Government to import were principally unilateral transfers (assume government imports good will) and military expenditures abroad.

Intragovernment transactions were primarily federal grants-in-aid to states and government payments to trust funds for civilian and military employees. Flows to the household sector consisted mainly of government receipts of personal income tax.

**GROSS INPUT**

Total expenditures on current account were used as a measure of the gross inputs for the government sector. Total expenditures, shown in table 22, were estimated following the method outlined in (101) using data in (95).

**ISC 0.32 Household**

Expenditures for goods and services by individuals in the United States appear as purchases by the household sector. Household output entries are similar to row entries of intermediate sectors. Essentially the main output of the household sector is human labor measured by labor wages and net proprietor's income. Other components are interest and depreciation charges.

**FLOWS TO AGRICULTURE**

The items in table 23 were part of the household accounts associated with agricultural sectors. Hired labor was defined as cash wages, perquisites and social security taxes paid by employers, and was obtained by states from (79, p. 9). Hired labor wages were allocated among commodity sectors within regions according to percentages expressing the relative number of labor hours required for each regional commodity sector.

Service building depreciation included only owned service buildings, fences, windmills and wells. An estimate of service building depreciation was obtained from (62, Oct. 1955) and adjusted to exclude depreciation on rented buildings. Farm rent, a part of all other industries (ISC 0.22), covers depreciation of rented service buildings.

Interest was defined as farm mortgage interest (from both institutional and noninstitutional lenders) and short-term loans. These data were available in (70, p. 112f).

Proprietor's income was defined as gross farm income (excluding government payments), minus production expenses and rent paid to off-farm landlords, plus additions in farm inventories. Gross farm income includes nonmonetary income such as home consumption of farm produce and an estimated gross rental value of farm dwellings. Proprietor's income was obtained, by states, from (96) and distributed according to percentages expressing the relative man hours required for regional commodity groups.

**TABLE 21. GROSS OUTPUT OF THE GOVERNMENT SECTOR (ISC 0.25), 1954. (MILLIONS OF DOLLARS)**

<table>
<thead>
<tr>
<th>Government</th>
<th>Total receipts</th>
<th>99,828.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td>69,946.00</td>
<td></td>
</tr>
<tr>
<td>State and local</td>
<td>29,882.00</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 22. GROSS INPUT OF THE GOVERNMENT SECTOR (ISC 0.25), 1954. (MILLIONS OF DOLLARS)**

<table>
<thead>
<tr>
<th>Government</th>
<th>Total expenditures</th>
<th>100,499.54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td>67,732.54</td>
<td></td>
</tr>
<tr>
<td>State and local</td>
<td>32,767.00</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 23. COMPONENTS OF HOUSEHOLD ACCOUNTS ASSOCIATED WITH AGRICULTURE, 1954. (MILLIONS OF DOLLARS)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hired labor wages</td>
<td>2,710.00</td>
</tr>
<tr>
<td>Service buildings depreciation</td>
<td>134.06</td>
</tr>
<tr>
<td>Interest (mortgage and short-term)</td>
<td>706.00</td>
</tr>
<tr>
<td>Proprietor's income after taxes</td>
<td>12,261.99</td>
</tr>
</tbody>
</table>
APPENDIX B

MAJOR MATRICES USED IN ANALYSIS

TRANSACTION MATRIX

Table A summarizes the distribution of value of all output in the United States, in 1954, by sector of origin and sector of destination. Often referred to as a flow chart or transactions matrix, this table is purely descriptive.

Each row in table A lists, for a designated sector, the distribution of output in 1954: The last element of the first row for sector 1.1 (livestock and livestock products in the Northeast region) shows a gross domestic output of 2,282.6 million dollars. The first entry in this row indicates that livestock and livestock products in the Northeast (sector 1.1) consumed internally 130.1 million dollars, mainly milk fed to calves, baby chicks, etc. Continuing across the same row, meat and poultry products (column 0.10) used 1,040.5 million dollars of sector 1.1 products. Dairy products (column 0.11) used 1,006.2 million dollars of sector 1.1 output, principally wholesale milk to be processed. Miscellaneous food (column 0.14) used 5.0 million dollars of sector 1.1 products. Textile products (column 0.17) used 6.9 million dollars—principally wool and mohair. Fertilizers (column 0.18) used 0.2 million dollars; and chemical products (column 0.19) used 0.6 million dollars of sector 1.1 products. Further along the first row in the final demand section, 1.1 million dollars of sector 1.1 products were exported (column 0.23), while imports (column 0.24) were 5.6 million dollars. Farm depletion of inventories (column 0.27) was 5.2 million dollars, and 103.1 million dollars of livestock products were consumed by the household sector (column 0.32), i.e., home consumption of farm livestock products. An analogous description can be extended to other rows.

Figures across row 1.1 represent the purchases of all other sectors from sector 1.1; likewise, figures down column 1.1 give a summary of all the purchases of this sector in 1954. The first entry is the intrasector flow of 130.1 million dollars, primarily milk fed to calves, baby chicks, etc. Livestock in the Northeast region (sector 1.1) also used: 263.9 million dollars of feed grains within the region (row 1.2); 31.6 million dollars of food grains within the region (row 1.3); 197.5 million dollars of forage crops within the region (row 1.4), mainly hay and pasture consumption; 10.8 million dollars of vegetables and fruit within the region (row 1.5); 0.4 million dollars of oil crops within the region (row 1.8); 58.1 million dollars of miscellaneous agriculture within the region (row 1.9), mainly horse and mule power and miscellaneous crops consumed by livestock, etc. Purchases of sector 1.1 from other regions include: 0.1 million dollars of livestock in the Corn Belt (row 2.1), mainly feeder cattle and sheep; 11.9 million dollars of feed grains in the Corn Belt (row 2.2); 3.4 million dollars of livestock in the Lake States (row 3.1); 6.1 million dollars of livestock in the Appalachian region (row 4.1); and 12.9 million dollars of livestock in the Northern Plains (row 8.1).

Industry purchases by sector 1.1 include: 650.8 million dollars of prepared feeds (row 0.13); 8.4 million dollars of chemical products (row 0.19), mainly veterinary supplies and insecticides; 53.2 million dollars of machinery and related services (row 0.20); 12.0 million dollars of petroleum products (row 0.21), mainly gasoline, grease and oil; and 269.5 million dollars of "all other industries" (row 0.22), mainly transportation, trade and farm rental fees. Sector 1.1 also purchased: 46.3 million dollars of government services (row 0.25); and 515.8 million dollars of household services, measured primarily by proprietor's profits, wages and interest payments. The 1954 outlays for other sectors may be summarized similarly.

Summarizing, for table A, the distribution of output of one sector to each of the other sectors may be traced by reading entries across the respective rows, and purchases from other sectors may be obtained by reading down the respective columns.

INPUT-OUTPUT COEFFICIENTS

The input-output coefficient matrix illustrated in table B provides estimates of the unit cost structure of each sector in 1954. Each ratio or entry shown in table B is calculated directly from data in table A. For example, internal flows in livestock in the Northeast region of 130.1 million dollars (row 1.1, column 1.1 in table A) divided by 2,282.6 million dollars (total domestic output at the end of row 1.1, table A) yields 0.05697, the entry at row 1.1 and column 1.1 in table B. Feed grain sales within the region to section 1.1 were 263.9 million dollars (row 1.2, column 1.1, in table A); this divided by 2,282.6 million dollars gives 0.11560, the entry at row 1.2 and column 1.1 in table B. The other entries in table B were derived similarly.

Each entry in table B shows the amount of goods and services required, from the sector named at the top, per dollar of output of the sector named at the left. For instance, each $1 of current output from livestock in the Northeast region (column 1.1) required from within the region: 5.7 cents internally (row 1.1); 11.6 cents of feed grains (row 1.2); 1.4 cents of food grains (row 1.3); 8.6 cents of forage crops (row 1.4); 0.4 cent of vegetables and fruit (row 1.5); and 2.5 cents of miscellaneous agriculture. Sector 1.1 purchased: 0.5 cent of feed grains from the Corn Belt (row 2.2); 0.1 cent of livestock products from the Lake States (row 3.1); 0.5 cent of livestock products from the Appalachian States (row 4.1); and 0.6 cent of livestock products from the Northern Plains (row 8.1).

Direct requirements from industry per $1 of livestock output in the Northeast (column 1.1) included purchases of: 28.5 cents of prepared feeds (row 0.13); 0.4 cent of chemical products (row 0.19); 2.3 cents of machinery and related services (row 0.20); 0.5 cent of petroleum products (row 0.21); and 11.8 cents of "all other industries" products (row 0.22). Parallel interpretations apply to other sectors.

INTERDEPENDENCE COEFFICIENTS

Table C, the interdependence coefficient matrix, illustrates a third view of the interrelations between sectors.
of the economy in 1954. It is based on figures in table A, but computed more directly from table B.

Table C shows the combined direct and indirect requirements of all sectors resulting from delivery to final demand of one dollar of output from each sector. Specifically, entries in each column in table C show the required change in gross output of the sector named at the left for the delivery of one dollar of goods and services to final demand from the sector named at the top. A delivery of $1 of livestock products (sector 1.1) to final demand required an increase in output of: $1.06 internally; 12.9 cents from feed grains (sector 1.2); 1.6 cents from food grains (sector 1.3); 10.7 cents from forage crops (sector 1.4); 0.5 cent from vegetables and fruit (sector 1.5), etc. Further down column 1.1, a delivery of $1 of livestock products (sector 1.1) to final demand required an increase in output of: 30.7 cents from prepared feeds (sector 0.13); 2.6 cents from fertilizers (sector 0.18); 4.7 cents from chemical products (sector 0.19); 15.5 cents from machinery and related services (sector 0.20); 2.9 cents from petroleum products (sector 0.21); and 55.4 cents from “all other industries” (sector 0.22). Corresponding interpretations can be applied to other columns in table C.

**Projected Changes in Gross Output (Table D)**

Table D illustrates, for each sector, the required change in gross output (absolute and percentage) that corresponds to specified changes in final demand for goods of agricultural processing sectors. The projected changes in final demand for 1960 and 1975 are given in table 12.28 The projections refer to agriculture sectors only, and do not indicate outcomes if similar projections were made in final demand for industrial sectors.

The construction of table D is explained by the following example. Projections for meat and poultry processing goods (sector 0.10) for 1960 were 10 percent (table 12) greater than in 1954. Final demand for sector 0.10 in 1954 was 13,172.4 million dollars (sum columns 0.23 through 0.32 for row 0.10, table A); 10 percent of 13,172.4 is 1,317 million dollars. Hence, changes in gross outputs were computed by multiplying the interdependence coefficients in column 0.10 of table C, in the respective rows, by 1,317—e.g., $1,317 million X .06762 (row 1.1, column 0.10, table C) = $89.0 million or 3.9 percent of the 1954 gross output of sector 1.1.

The interpretation of table D is as follows: The projected change in final demand from 1954 to 1960 for processed meat and poultry (ISC 0.10) is 10 percent (table 12). Accordingly, the required increase in output to meet this projected demand is: (in column 0.10 under 1960) 89.0 million dollars or 3.9 percent from livestock in the Northeast; 12.0 million dollars or 4.1 percent from feed grains in the Northeast; 1.4 million dollars or 17 percent from food grains in the Northeast, etc. A parallel interpretation is given to the other columns.

The column labeled “total” (both for 1960 and 1975) shows the total requirements of each sector (absolute and percentage) associated with all projected agricultural processing product final demands. For example, 187.9 million dollars or 8.2 percent increase in livestock output (sector 1.1) is associated with a projected final demand of 10 percent in meat and poultry processing, 10 percent in dairy products, 10 percent in miscellaneous food products, 15 percent in vegetable and fruit products, 17 percent in tobacco products, and 18 percent in textile products (table 12). A similar interpretation is given to the other entries under “total” columns.

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28For further details see the section “Projected Input-Output Needs” in the text.
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