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Application of Input-Output Analysis To a Regional Model Stressing Agriculture

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SUMMARY

This study is an application of input-output analysis to a 21-sector model of the United States economy in 1949. Major emphasis is on the relationship between agricultural production in geographic regions and between agriculture and the industries which (a) process agricultural products and (b) provide productive factors to agriculture. The analysis is based on the relationships in equation (i) below where X is the matrix of outputs of specified intermediate producing sectors, A is the matrix of technical input-output coefficients and Y is the vector of final demands. One objective of this study is examination of the input-output coefficients in A , to determine the amount of product from particular

$$(i) AX = Y$$

$$(ii) A^{-1}Y = X$$

producing sectors used per dollar of output of other producing sectors. Another objective is examination of the interdependency coefficients in A^{-1} , to determine the relationship of final demand for the product of one sector with output of the various other sectors.

In the analysis, agriculture has been divided into six regional crop-producing (primary output) sectors and the same number of livestock-producing (secondary output) sectors. Industry has been divided into those sectors representing processing, transportation and trade of (a) food crops, (b) nonfood crops, (c) livestock products, (d) machinery and fuel, (e) miscellaneous supplies and (f) all other services and products.

The total of industry input-output coefficients for primary agricultural sectors shows the Corn Belt, of all major crop sectors, to be most dependent per dollar of output on nonagricultural sectors. The Corn Belt has a high total industrial coefficient because it uses a relatively large amount of items such as fertilizer, fuel and machinery per acre but at the same time (a) produces crops with lower acre values than the fruits, vegetables, cotton and tobacco of other regions and (b) has most of its forage acreage under cultivation. In contrast, the total industrial coefficient per dollar of primary output is lowest for the Great Plains. This low coefficient stems largely from the fact that much of the Great Plains is in native vegetation requiring little or no input of industrial expense items. The total industrial input-output coefficient also is relatively low for the Southeast where such crops as cotton, tobacco, citrus and other

fruits and vegetables have high per-acre values, even though the input of industrial products per acre is relatively high.

For secondary agricultural production, the total industrial input coefficient is highest for the Northeast and Far West. It is high in these regions because both import a large proportion of livestock feeds which are transported for long distances. (The industrial component of the feed input includes cost of processing and transportation as well as other handling costs.) The total industrial coefficient for secondary agriculture is lowest for ranch areas where inputs for range sheep and cattle are mainly feed produced from native grasses.

The interdependence coefficients for primary agricultural sectors in relation to food processing sectors show the following: A change of \$1.00 in the final demand for processed food (sector 13 in the text) is associated with only a 29-cent increase in output of all agricultural sectors. The remainder of the dollar change in processed foods is represented by the inputs from other industrial or nonagricultural sectors. In other words, the "food bundle," representing primary agricultural products, moving into final demand is made up of more than two-thirds of industrial inputs and less than one-third of farm inputs.

Agricultural sectors (sectors 1 through 12 in the text) were highly dependent on industries (sector 18 in the text) not engaged in processing farm products in 1949. These same industries were not highly dependent on agriculture. The amount of sector 18 products used per dollar of final demand for agricultural products ranged from 0.3928 for secondary agricultural products in the Corn Belt to 0.4768 for primary agricultural products in the Intermountain States. In contrast, the amount of agricultural products used per dollar of final demand for sector 18 products ranged from 0.0011 for secondary output in the Intermountain States to 0.0106 for primary output in the Corn Belt.

The limitations of input-output analysis applied to agriculture are reviewed in the text. The main limitations are the linear or *fixed mix* restrictions forced into intersector relationships by the model. Hence, the coefficients mainly describe relationships at a particular point in time insofar as agricultural relationships are concerned. Differential income elasticities of demand for farm products do not allow projections to future levels of national income.

Application of Input-Output Analysis to a Regional Model Stressing Agriculture¹

BY JOHN A. SCHNITTKER AND EARL O. HEADY

This study is a continuation of an earlier one which was initiated to establish quantitative relationships among agricultural and nonagricultural sectors of the economy. These relationships are of interest because of increased interdependence of sectors as the economic structure of our society becomes more complex. Agriculture is becoming more dependent upon the rest of the economy for its inputs. In the earlier study, Peterson and Heady (34) estimated that input purchases by farmers from industry increased from 28 cents per dollar of crop output in 1929, to nearly 50 cents per dollar of crop output in 1949. Future data are likely to reflect even greater interdependence between agriculture and industry.

The national government has assumed, and is likely to maintain, an increased role in consciously affecting the nature and the intensity of economic activity. If this task is to be carried out intelligently, prior knowledge of the structure of the economy is essential. Historically, the source of such knowledge has been research considering small segments of the economy alone. Input-output analysis (27), the technique used in this study, allows a general equilibrium analysis of the relationships among all economic sectors. It permits, under the limitations of linear coefficients, consideration of the interrelationships between various sectors of the economy resulting from outside disturbance such as a change in final demand.

OBJECTIVES

The over-all objective of this study is to establish interrelationships among various sectors of agriculture and between agricultural and nonagricultural sectors of the United States economy for 1949. Specific objectives relating to this end include:

1. To formulate a model of the economy of the United States in which relationships among agricultural regions and between agricultural regions and the rest of the economy may be observed.

2. To provide estimates of the trade patterns among economic sectors for a given time period and to transform these data into coefficients (a) expressing the input-output relationships between economic sectors and (b) expressing the interdependence between economic sectors.

A further objective, associated with the great volume of data required to empirically develop an input-output model, is evaluation of data requirements for the model relative to data currently available.

THE MATHEMATICAL MODEL OF THE ECONOMY

In the formulation of the Leontief or input-output system (26, 27), the economy of any political subdivision is conceived as consisting of a number of "homogeneous" producing industries or sectors. These sectors engage in trade with each other and with other national economies. Also, they may sell goods for immediate human consumption. The output of each economic sector is defined as the sum of the sales by the sector to all other sectors, including sales for export, to government and to individuals. Sectors whose demand for products arises out of their own decisions to produce goods are called "intermediate." These include all agricultural and industrial sectors. Sectors whose demand for goods arises partly for other reasons, such as political decisions or individual consumer preferences, are called "autonomous." Government, foreign trade and households are usually placed in this class.

FLOWS BETWEEN SECTORS

The first step in input-output analysis is derivation of flows from producing sectors to consuming sectors. These flows may be aggregated on either a gross or net basis. Flows within any economic sector, such as crop seeds used on the farm where they are grown, are not explicitly considered in this input-output study. Only net outputs are considered. The net output (X_i) of any intermediate sector is represented as the sum of sales to other intermediate sectors (x_{ij}), plus sales to the final demand or autonomous sectors (y_i).

Net output is:

$$(1.1) X_i = \sum x_{ij} + y_i \quad (i, j = 1, 2, 3 \dots n).$$

Equation 1.1 may also be written as:

$$(2.1) X_i - \sum x_{ij} = y_i \quad (i, j = 1, 2, 3 \dots n).$$

The empirical counterpart of equation 1.1 is expressed as a transactions matrix or table showing the value of the products of each sector flowing to all other sectors in the given time period, and the sum of all such flows

¹Project 1135, Iowa Agricultural and Home Economics Experiment Station.

for each sector. Construction of a transactions matrix (table 2) is the major step in an input-output study of an economy in terms of time and other resources required. It may be the only step if the purposes of the study are to describe the structure of an economy. A method of projecting the mono-period relationships to future time periods and limitations of the method are discussed subsequently.

Data of the transactions matrix may be used to compute the relationships between the net output of each sector and the inputs furnished to that sector by other sectors. These relationships are expressed as production coefficients (a_{ij}) and are defined as:

$$(3.1) a_{ij} = x_{ij}/X_j \quad (i, j = 1, 2, 3 \dots n)$$

or

$$(4.1) x_{ij} = a_{ij}X_j.$$

Each a_{ij} represents the dollar's worth of the product of sector i required by sector j per unit of output of sector j . In an empirical model, production coefficients are computed from the data in the transactions matrix by dividing the value of each of the inputs used by each sector (as shown in column j of the transactions matrix) by the net output (X_j) of the sector.

The elements of the transactions matrix from which the coefficients of production are computed are single-valued. Therefore, the coefficients of production are also single-valued. Technically, the input-output system assumes that the production function of each producing sector in the economy is linear and homogenous of degree one. A change in the output of any producing sector is assumed to require a fixed change in the output of each input-furnishing sector; thus, perfect complementarity between inputs of furnishing sectors and a zero marginal productivity for the input of any single furnishing sector is implied.

The ratios computed from the transactions matrix form the matrix of coefficients of production shown in empirical form as table 3. While essentially descriptive, they also may be put to analytical use in estimating the direct effects of a change in output of any sector j upon the sectors supplying the inputs to sector j . Examples of this procedure appear later.

Algebraic substitution permits the data of the transactions and input coefficients matrices to be put to further analytical use. Reference to equation 4.1 indicates that equation 2.1 may be rewritten as:

$$(5.1) X_i - \sum a_{ij}X_j = y_i.$$

The system of equations represented by equation 5.1 expresses consumption by autonomous sectors, or the "final bill of goods," as a function of net outputs (X_i) and the relationships between intermediate sectors in the economy (a_{ij}). The matrix of coefficients of this system of equations, represented empirically in table 3, may be inverted to obtain coefficients expressing the net output of any sector of the economy (X_i) as a function of the parts of the final bill of goods (y_i). The coefficients of the new system of equations are the elements of the inverse matrix of production coefficients (table 4). This system of equations can be represented in matrix form as:

$$(6.1) A^{-1}Y = X$$

where A^{-1} represents the inverse of the matrix of technical input-output coefficients, Y is the matrix of final demands and X is the matrix of output for producing sectors. After the technical or input-output ratios have been computed from the transactions matrix, it is a relatively simple procedure to compute the inverse matrix in a model of the present size.

In a simple case which may be solved without use of a machine, we have the matrix of technical input-output coefficients:

$$A = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \text{ its inverse, } A^{-1} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

and the identity matrix:

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

The inverse matrix provides the interdependence coefficients and is obtained as the product $AA^{-1} = I$. In this case:

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

By matrix multiplication:

$$\begin{bmatrix} 2c_{11} + c_{12} & c_{11} + 2c_{12} \\ 2c_{21} + c_{22} & c_{21} + 2c_{22} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Since corresponding elements are equal:

$$\begin{aligned} 2c_{11} + c_{12} &= 1 & 2c_{21} + c_{22} &= 0 \\ c_{11} + 2c_{12} &= 0 & c_{21} + 2c_{22} &= 1 \end{aligned}$$

By elimination, the interdependence coefficients are:

$$\begin{aligned} c_{12} &= -0.333 & c_{21} &= -0.333 \\ c_{11} &= 0.667 & c_{22} &= 0.667 \end{aligned}$$

The elements of the inverse matrix are the coefficients of a system of equations expressing net outputs as a function of the parts of the final bill of goods. Each coefficient indicates the amount the net output of a given sector must change to make it possible for sector j to add \$1.00 to its bill of goods. Thus, in column 1, row 16, of table 4, the coefficient 0.164 indicates that each \$1.00 of final demand for products of sector 1 is associated with 16 cents worth of net output of sector 16.

Once the inverse is available, numerous assumptions may be made concerning changes in final demand (y_i) and the resulting net outputs (X_i) computed and interpreted in the framework of the limitations of the analytical technique.

THE ECONOMIC MODEL OF THE ECONOMY

First decisions in initiating an input-output study include determining the period to be studied and the composition of the sectors of the economy to be related. The year 1949 was selected for this study because the data on resource inputs and agricultural production were more adequate than in this year. The publications

providing this information are included in the attached bibliography, and the data are described in some detail in one of the publications listed (36).

The main model of this study includes 12 agricultural sectors and 6 industrial sectors. The agricultural sectors include the 6 regions shown in table 1, plus a crop and livestock sector for each of these. Actually, two models are completed in this study: First, the 18 sectors mentioned above and government and foreign trade are considered as intermediate sectors, and, in Appendix B, 18 sectors are considered as intermediate, with government and foreign trade considered as autonomous.

DEFINITION OF AGRICULTURAL SECTORS

Inclusion of a complex national economy in a relatively simple model requires a high level of aggregation of inputs and outputs for the various sectors. Since an objective of this study is to observe interdependence between agricultural regions of the United States, spatial aggregation of agricultural production is required. Two general procedures applied in aggregation of data for input-output models are (a) to define sectors in such a way as to minimize intersector transactions, and (b) to maintain the highest possible degree of similarity of input structures among the products of any sector. The second procedure is followed roughly in forming agricultural regions and sectors. Agricultural regions used in the analysis are based on generalized type-of-farming areas (51). No states were divided, since division introduces greater data problems. Regional representation of states is shown in table 1.

Procedure (b) suggests a division of agricultural regions along type-of-product lines. Crop production fits the criteria for extractive or primary activity, while livestock production is a processing or secondary activity. Since the input structures of the two kinds of production differ so greatly, each agricultural region is subdivided into two input-output sectors. Crop production in regions 1 to 6 (table 1) is designated as sectors 1 to 6 in the remainder of this study. Livestock production in the respective regions is designated as sectors 7 to 12. The *mix* of the primary and secondary agricultural products of each region is, of course, as heterogeneous as the crops and livestock which are aggregated into it.

INDUSTRIAL SECTORS

Industrial sectors are defined in a manner to permit expression of relationships between agriculture and

certain components of the nonagricultural economy. Two general categories are included: (1) industries which process similar agricultural products and (2) those which provide different inputs to agriculture. Industry aggregation is based, mostly on a detailed study of the United States economy made by the Bureau of Labor Statistics for 1947 (59, 60 and 61). The industry sectors are:

Sector 13. Industries processing the products of primary agriculture, chiefly for food use, but including livestock feeds.

Sector 14. Industries processing the products of primary agriculture, chiefly for nonfood use.

Sector 15. Industries processing the food products of secondary agriculture.

Sector 16. Industries providing machinery, machine services, fuel and oil to all sectors of the economy.

Sector 17. Industries furnishing fertilizers, seeds and other supplies to agriculture, as well as many products to other sectors.

Sector 18. All other industries, including most services.

The industry classification adopted is based also on aggregation principles enumerated earlier. For example, similarities in production functions and minimization of intersector trade are the basis for inclusion of feed processing in sector 13, which includes all other milling operations. Also, in the factor-supplying sectors, the same principle is followed in aggregating machinery and vehicle production and repair in a single sector.

Since agriculture is subdivided both geographically and by process, industry sectors might also be handled in the same way. The regional model developed by Isard included industrial product data within regions. He cautions, however, that for such a model ". . . appropriate data are not currently available" (21, p. 326). Moses (30) developed a similar empirical model, using relationships between national industries and associated data on regional trade to estimate regional and interregional trade coefficients.

Given the data problems of regional consideration of industry, along with the objectives of this study to stress agricultural production, regional consideration of industries seemed unimportant. Hence, the general classification of industries shown above was used.

Activities which do not fit the criteria for industry sectors, but which are closely related to industry, include foreign trade and government. In input-output models, exports are treated as "inputs" to the foreign trade sector, while imports are considered to be the "output" of the same sector. Government purchases and government services are the "inputs" and "outputs" respectively, of the government sector. In the previous input-output study of agriculture (34) both these activities were treated as intermediate sectors in a 5-sector model of the United States economy. However, interpretation of estimated relationships was difficult. Treatment of foreign trade and government as intermediate or autonomous sectors is largely arbitrary.

There is little theoretical basis for calling them intermediate sectors. By definition, inputs absorbed by a valid intermediate sector are physically instrumental in the production of the net output of the sector. But the inputs to foreign trade (exports) are very unlikely to be related physically to the trade sector's output (imports). Both imports and exports depend upon a series of political relationships and upon the economic and technological structure of the domestic and foreign economies. The case for treating the government sector as autonomous is less clear. Many inputs ab-

TABLE 1. COMPOSITION OF AGRICULTURAL REGIONS BY STATES.

Region 1	Region 2	Region 3
Maine	Ohio	Virginia
New Hampshire	Indiana	West Virginia
Vermont	Illinois	North Carolina
Massachusetts	Wisconsin	South Carolina
Rhode Island	Michigan	Georgia
Connecticut	Minnesota	Florida
New York	Iowa	Tennessee
New Jersey	Missouri	Alabama
Pennsylvania	Kentucky	Mississippi
Delaware		Arkansas
Maryland		Louisiana
Region 4	Region 5	Region 6
North Dakota	Montana	Arizona
South Dakota	Idaho	Washington
Nebraska	Wyoming	Oregon
Kansas	Colorado	California
Oklahoma	New Mexico	
Texas	Utah	
	Nevada	

sorbed by government are physically related to the services provided by government. Too, government, like industry, might be considered to have a "demand schedule," reflecting roughly the desire by its citizens for services.

As explained earlier, the two sectors are treated alternately as intermediate and autonomous in this study. The model with 20 intermediate sectors is discussed most completely; the other is shown in Appendix B. Minor differences between interdependence coefficients in the two cases are summarized there.

Households fit the criteria for autonomous sectors because of the independent nature of their decisions to absorb inputs. To a limited extent, individuals (households) absorb inputs in order to produce the quantity and quality of labor service demanded by intermediate sectors. But in a developed economy, much consumption cannot be justified on the grounds that it is necessary to production. Designation of foreign trade, government and households as sectors 19, 20 and 21 completes the model of the economy employed later.

CONCEPTUAL AND THEORETICAL PROBLEMS

In the usual input-output formulation, the flows between intermediate sectors consist of goods which are still to undergo some stage of processing. Only goods ready for final consumption enter final demand sectors. Thus input-output analysis involves double counting to the extent made possible by the aggregation system. In practice, certain products appear to qualify equally as well as flows to intermediate or final demand sectors. Many farm produced foods might be assigned either to a processing or a consuming sector, since they undergo relatively minor processing. In the 200-sector table of the Bureau of Labor Statistics, not only fruits and vegetables, but also secondary products such as milk and eggs are treated as direct flows from agriculture to households (61).

Choice of the direction of flow for each product must be guided partly by the objectives of the study, but equally by the availability of data for one method or the other. For this study, all farm commodities' sales have been directed to a processing sector if data permitted, leaving home-used farm products as the only direct contribution of agricultural sectors to final demand.

The theoretical foundations of input-output analysis are given in detail elsewhere (27) and are implied also in the mathematical model above. Briefly, the flows of goods and services from any producing sector are defined as a function of the (a) derived demands of other sectors and (b) the final demand for products of the first sector, all considered in the framework of the technological and price structure of the economy.

The crucial theoretical assumption is that of fixed coefficients of production. Whether or not this assumption is a severe limitation was studied by Cameron (7) who observed 178 Australian industry subclasses. He concluded tentatively that the fixed coefficients may be a reasonable approximation for the industries studied, since he found little evidence of materials or price substitution. Leontief and associates (26) discuss the possibility of checking the production functions estimated in input-output analysis by use of engineering data.

Another theoretical problem involves the relationship between total inputs and total output of any sector (see table 2). The use of input-output models for projection implies that the period selected is somehow representative of equilibrium conditions. In the long run, if an industry is to operate, the value of output must equal total cash cost plus the opportunity or reservation cost for inputs. Hence, the convention was adopted here, as in the 1947 Bureau of Labor Statistics study, to reconcile total value of inputs and total value of output for each intermediate sector. The somewhat arbitrary means of doing so are explained later.

A special assumption about geographical regions and their products was required for the regional model, especially to estimate feed grain supplies available for sale to industry sectors, or imports from other agricultural sectors. In regions as large as those of this study, transportation costs are often greater between points in a region than between points in different regions. Thus, region A may be a corn-surplus area and region B a deficit area. Yet data may show that corn was shipped from B to A in a given year. However, because of lack of data, a simplification was adopted—treating the region as a point—thus assuming intra-regional transportation costs to be zero. Supplies of commodities in a region are then assumed to be available to all producers in the region at the same cost. Producers in the region will import them only when the quantity of a good produced in the region is less than that demanded by users in the region. Errors involved in the stated assumption are expected to be minor.

VALUATION OF PRODUCTION

The need to aggregate, and thus to have each sector include several unlike products, requires the use of a common unit of measure in describing intersector transactions. Monetary units are the obvious choice. Thus, the equations presented earlier are interpreted as expressing values, rather than physical units. Flows of products from one sector to another are valued F.O.B. the producer. This means, for example, that "prices received by farmers" is the series used for valuing farm products sold for processing. However "prices paid by farmers" is not the correct series for valuing the flows of products from industry to agriculture, since this series includes marketing margins. Specific valuation problems are discussed in subsequent explanations of trade patterns.

ESTIMATING PROCEDURES AND DATA SOURCES

After a tentative model of the economy has been formulated, the next step is to determine the value of the products flowing between the sectors of the economy in the period selected. This is the most time-consuming phase of the input-output analysis. Even in the simple model presented here, the number of separate sector transactions to be estimated is imposing. Also, when aggregation is at a high level, each estimate of an intersector transaction is made up of the transactions of the various components of the aggregate sector.

TABLE 2. DISTRIBUTION OF THE VALUE OF INPUTS AND OUTPUTS OF THE UNITED STATES ECONOMY, 1949.*

Sector number	Primary agriculture sectors						Secondary agriculture sectors					
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
1	.....	.....	.....	.....	.....	.....	644.9	.....	2.6	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	26.7	2,807.6	3.6	0.2	2.9	7.7
3	.....	.....	.....	.....	.....	.....	.....	.....	925.0	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	1.6	0.4	1,377.5	11.1	13.1
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.2	419.5	0.1
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.1	359.0
7	94.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	425.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	151.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	234.6	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	84.7	.....	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	.....	70.0	.....	.....	.....	.....	.....	.....
13	2.7	1.7	12.8	3.4	0.2	0.3	530.7	525.4	372.8	240.2	54.0	218.1
14	0.6	1.9	7.2	1.4	0.1	0.4	3.3	5.8	2.3	1.6	0.5	1.4
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	159.5	739.9	449.9	473.1	155.7	267.7	63.2	206.3	62.9	79.4	24.8	33.3
17	164.2	398.5	397.8	143.3	39.3	142.1	6.2	22.1	8.0	9.9	3.0	3.3
18	279.8	1,382.3	957.4	927.3	280.5	468.6	361.9	1,000.6	330.1	382.0	115.2	177.0
19†	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20†	86.8	351.4	139.6	194.2	64.9	128.4	32.4	96.9	23.5	40.1	13.1	16.0
21	503.2	2,352.5	2,195.3	2,146.9	450.2	1,006.2	562.2	2,707.9	557.4	842.6	302.6	368.1
Total inputs	1,291.0	5,653.4	4,311.9	4,124.3	1,075.5	2,083.8	2,231.5	7,374.3	2,288.4	2,973.7	946.7	1,197.1

* Each row shows the distribution of the output of the industry named at the left. Each column shows the input distribution for purchasing industry named at the top. All figures are in millions of dollars. Dashes denote zero or near-zero entries.

† The foreign trade and government sectors are considered alternately in the text as (a) intermediate and (b) final demand sectors.

TABLE 2 (continued)

Sector number	Industry sectors										Net output
	Crop food products	Nonfood crop products	Livestock products	Machinery and fuel	Miscellaneous supplies	All other products	Foreign trade	Government	Households		
1	346.4	60.2	.....	.....	43.7	19.1	16.6	64.9	92.6	1,291.0
2	964.9	708.9	.....	.....	93.6	283.7	190.5	345.3	218.0	5,653.4
3	781.2	1,266.9	.....	.....	31.1	93.0	533.8	331.8	349.1	4,311.9
4	846.9	587.5	.....	.....	56.7	136.8	292.4	722.2	78.0	4,124.3
5	339.5	43.8	.....	.....	29.4	6.6	23.8	198.4	14.1	1,075.5
6	1,166.6	203.7	.....	.....	34.7	20.7	91.7	179.8	27.4	2,083.3
7	.....	1.4	1,986.7	.....	.....	.....	.....	.....	149.1	2,231.5
8	.....	17.6	6,432.8	.....	.....	.....	.....	.....	498.8	7,374.3
9	.....	2.4	1,488.1	.....	.....	.....	.....	.....	646.1	2,288.4
10	.....	41.1	2,389.5	.....	.....	.....	.....	.....	308.5	2,973.7
11	.....	37.3	764.9	.....	.....	.....	.....	.....	59.8	946.7
12	.....	11.9	1,046.8	.....	.....	.....	.....	.....	68.4	1,197.1
13	.....	235.2	267.8	.....	48.2	2,252.0	373.9	492.4	13,835.0	19,466.7
14	1,027.0	.....	30.0	452.0	73.0	6,823.0	701.9	240.2	3,822.7	13,196.2
15	728.0	428.0	.....	.....	43.3	2,328.9	266.0	818.5	15,705.0	20,317.7
16	159.5	54.2	70.3	.....	113.9	7,807.7	2,168.3	918.1	11,800.0	25,807.5
17	153.8	150.6	38.7	448.1	.....	2,663.2	606.4	141.5	1,082.5	6,622.8
18	3,334.2	2,271.4	1,057.7	13,395.8	2,615.0	.....	6,670.8	18,357.3	129,427.8	183,792.8
19†	1,677.4	588.9	157.0	104.0	100.1	3,964.2	.....	3,843.0	.....	10,434.6
20†	764.9	997.9	229.3	1,451.8	452.5	27,594.5	381.6	.....	23,394.0	56,453.0
21	7,176.4	5,487.3	4,358.2	9,955.8	2,887.6	129,799.3	.....	33,268.5	2,415.0	209,344.4
Total inputs	19,466.7	13,196.2	20,317.7	25,807.5	6,622.8	183,792.8	12,317.1	59,922.0	203,992.0	.....

Nearly all agricultural data were available in their earliest form in Agricultural Statistics (46), with partial revision in later publications. The most recent revisions were used. Industry, trade and government data came from many sources, but the transactions table of the 1947 interindustry study (61) was the basic reference for the latter sectors.

Sector explanations which follow are mostly in terms of output, since output data were more readily available than input data. Each row entry in a transactions matrix (table 2) is also a column entry. Thus, input explanations are implicit in output explanations. No attempt is made here to provide a detailed description of the methods and sources used to estimate net outputs and their distribution. Such a description is available from another source (36).

ESTIMATING THE OUTPUT OF PRIMARY AGRICULTURE

An early step was to estimate the total production of each crop product, both for regions and the United

States in 1949, and to distribute the products of each primary sector to other sectors. This involved both conceptual and data problems. Seeds, for example, offered the possibility of interprimary flows of products. However, only the seed output and the total seed requirements of crop sectors could be estimated from available data. No trade pattern between crop sectors could be established. As a result, seeds normally traded were consigned to industry sector 17, which in turn, supplied seeds bought by farmers. This procedure eliminated the only possible interprimary sector transactions.

Many products of primary agriculture have multiple end uses. For example, corn produced in sector 2 (Corn Belt) may be fed to livestock in region 2 or in another region. It also may go to sector 13 to be processed for human food, to sector 14 to be turned into alcohol, to the Commodity Credit Corporation as unredeemed loan collateral, or to other uses. The degree of diversity of use varies greatly. Mung beans grown in Oklahoma (sector 4) go exclusively to sector 13 for processing, while wheat grown in the same region has a complex distribution pattern.

Since available data included only the national distribution of major primary commodities to various industries, regional distribution patterns were estimated from these national data. The supply of multi-use grain to be allocated from each region to all national industries was equal to the total production in the region minus the amount of the commodity fed on farms in the region or shipped to other regions to be fed. Each regional supply for nonfarm uses was allocated to various industry sectors, using coefficients expressing the proportion of the total commodity supply for nonfarm uses taken by the using industry sector. For example, if 15 percent of all corn not fed on farms went to national sector 13, it was assumed that each corn-supplying region consigned 15 percent of its surplus to sector 13. Regional distributions of crop production in 1949, with 1929 comparisons, are given for major crops in table 7.

PRIMARY AGRICULTURAL PRODUCT FLOWS BETWEEN REGIONS

Grains fed with only minor processing, and all forages fed, were treated as flows from primary to secondary agricultural sectors. Grains fed after intensive processing were defined as flows from an industry sector to livestock-producing sectors. In regions where total production of a grain used for feed was greater than the quantity of the grain fed in that region, it was assumed that no imports were made—even though minor border trading was shown, as explained earlier. In regions where total production of a given grain was less than the quantity fed in the region, it was assumed that the total amount produced was fed to livestock in the region, that imports were required to fill the deficit and that the region contributed none of the supply for nonfarm uses.

Hay available for use by each regional secondary sector was estimated as production by the regional primary agricultural sector, adjusted by the inventory change in 1949, and for small quantities of hay shipped to other regions. Forages other than hay were pasture, silage and fodder. None of these entered into interregional trade, so the production by each primary sector was taken as the consumption by the secondary agriculture sector in the region.

Minor intraregional flows from primary to secondary sectors included soybeans, peanuts, cottonseed and other products. The basic data sources for this group of products were (23, 24, 42, 46 and 47). A detailed commodity description of intraregional feed flows appears in table A-1, Appendix A.

PRIMARY AGRICULTURAL PRODUCT FLOWS BETWEEN REGIONS

Only corn and oats of all feed grains were considered to have entered into interregional trade. All regions produced more than enough of other feed grains to fill the demand for on-farm feeding. Given the assumption of zero transportation costs within regions, the regions required no imports of these grains. Corn fed to livestock exceeded corn produced in the region in sectors 7, 11 and 12 (regions 1, 5 and 6, respectively). Deficits were filled by shipments from other primary agriculture sectors, as estimated from shipment data (20) and

simple transportation-location principles. Data indicated that sector 2 (Corn Belt) supplied all the corn needed for on-farm feeding in sector 7 (Northeast). The other region adjoining the Northeast, region 3 (South), had no corn surplus. Sector 4 (Great Plains) had corn to export but also had a freight rate disadvantage compared with sector 2. Shipment data indicated large shipments of corn to sectors 11 and 12 from both sectors 2 and 4. Imports by these two sectors from sectors 2 and 4 were estimated from the total corn deficit of sectors 11 and 12, and the fraction of the total corn imports from sectors 2 and 4 indicated by a carload waybill sample (20). Similar methods were used for oats. Shipments of hay between regions were also estimated from carload waybill data. The trading pattern appears elsewhere (36) and is not detailed here.

PRIMARY AGRICULTURAL PRODUCT FLOWS TO INDUSTRY SECTORS

Industry sectors shipped most farm produced foods and fibers to consumers in 1949. Data on the quantities of primary agricultural products purchased as inputs by various industry sectors were found to be relatively complete on a national level. However, little information was available indicating the regional distribution of primary commodities to various industrial uses. As a result, coefficients expressing the proportions of many products used nationally by various industries in 1949 were used to estimate regional flows to industry and final demand sectors. Use of national coefficients requires the assumption that each unit of a commodity produced in one region is a perfect technical and economic substitute for each unit of a commodity produced in another region. This assumption is not always realistic. However, only exhaustive study of the location of different kinds of industrial users relative to the location of specialized producing areas could uncover the true relationship of agricultural regions to industry sectors. The basic data sources for the estimates in this section were (46, 48, 55 and 60).

Sector 13. Sales by primary agricultural sectors to industry sector 13 included grains and oil crops for food use of livestock feed, fruit and truck crops for processing, and other minor crop products. Multi-use commodities were allocated to the industry sector from each primary sector using the national coefficients explained above. Other crops, such as fruits and vegetables, were allocated entirely to sector 13. Values of primary commodities processed by sector 13 are given in table A-2 of Appendix A.

Sector 14. Cotton was the most important primary commodity processed by sector 14 industries in 1949. Others were tobacco, vegetable oilseeds and small quantities of grains for use in making alcohol. The supply of each commodity in each region and the fraction of the national supply used by sector 14 industries determined the quantity of each commodity consigned to sector 14 by the primary agricultural sector. Commodity flows in the group are detailed in table A-3 of Appendix A.

Sector 17. Since seed transactions between regions could not be isolated, farm sales of field crop seeds were consigned to industry sector 17, which provided miscellaneous supplies to agricultural sectors. Alfalfa, grasses,

soybeans, hybrid corn and potatoes were among the important seed crops.

Sector 18. Farm forest products were the only important products of primary sectors which did not fit into the processing activities of one of the other industry sectors. Included also in the primary commodities consigned to sector 18 were small residual quantities of several commodities, not assigned elsewhere because of estimating errors or changes in inventories. They were consigned to sector 18 as an alternative to setting up an unallocated sector, as has been done in some other studies of this type (9, p. 107).

Sector 19, foreign trade. Allocations of grains, oil crops, cotton, vegetables and tobacco to export was made in the same manner described earlier for allocation to processing sectors. In the absence of data showing which regions provided the quantity of a crop demanded for export, each primary sector was considered to provide a share of the national export total. The size of each regional contribution to export was determined by (a) the quantity of a commodity exported relative to other nonfarm uses and (b) the relative contribution of each primary agricultural sector to the national supply of the commodity after on-farm uses in the region were filled. Data were from (41 and 46).

Sector 20, government. Purchases of primary products by government were defined to include only government procurement, either for overseas shipment in relief programs or through deliveries by producers in connection with price-support programs. Regional allocations were made using national coefficients as described above. Data were from (46 and 55).

Sector 21, households. Primary farm products used directly by households were defined to include only those used by farm households. The choice was made somewhat arbitrarily, since large quantities of fruits and vegetables undergo only minor processing enroute to other consumers and might have been considered as direct flows from agriculture to final demand.

EVALUATING PRIMARY AGRICULTURAL PRODUCTS

For most commodities, physical quantities were distributed to using sectors before values were placed on the commodity. Feeds fed within regions, but listed as a flow from primary to secondary sectors, and a few commodities listed initially by value were exceptions to this valuation procedure. The annual series, "prices received by farmers," was selected as consistent with the producer's value concept used in the study. Prices for each commodity in each region were computed as a weighted average of the prices received by farmers in the states of each respective region.²

ESTIMATING THE OUTPUT OF SECONDARY AGRICULTURAL SECTORS

The manure by-product of animal feeding is an im-

²Feeds fed in vertically integrated farm firms posed a special valuation problem. Use of annual "prices received by farmers" resulted in estimates of total inputs in excess of total outputs for each secondary agricultural sector. Input/output ratios varied from 1.13 to 1.42, with the size of the ratio roughly proportional to the volume of unmarketed feeds fed to livestock in the region. The method adopted was to consider (1) all other inputs to secondary sectors and (2) output estimates of secondary sectors, as firm estimates, and to take the value of feeds produced and fed in the region as the difference between net output of the secondary sector and the cost of all other inputs. This equated total inputs and total outputs for these sectors.

portant input to primary agriculture. Volume and value of production of this by-product were estimated as described in (36) and listed in the transactions table as a secondary sector output and primary sector input within each region.

The main products of secondary sectors were meat animals and animal products. Value of output of all products was readily available by states, but lack of data limited the distribution pattern of secondary agricultural products in the model. It was intended initially to estimate the trade pattern of feeder cattle and sheep between regions—the output of certain regions being the inputs of other regions. However, data permitting such estimates were available only for one state (57). Data in Agricultural Statistics (46) giving feeder cattle movements into eight Corn Belt states without designation of the source of the shipments were not adequate for the estimates proposed.

These data limitations forced a revision in concept, and somewhat reduced the value of the study since regional interdependence estimates were a primary objective. Value of all cattle and sheep produced in each region in 1949 less the value of home-used products was consigned directly to sector 15, which processed secondary agricultural products. The fact that the animals may have been fed in several regions in a single year was accounted for in the "value added" estimates but was not reflected in the input accounts of the agricultural sectors purchasing the livestock for feeding. Hog production and sales to sector 15 were handled similarly. However, feeder pig transactions are relatively minor compared with beef cattle and sheep feeder movements.

Other products of secondary agriculture are dairy products, eggs and poultry. The value of farm production of each, less value of home-used products, was consigned to sector 15 for processing. Wool and mohair shorn on the farm were relatively small items and appear in the input-output table as sales to sector 14 which processed vegetable and animal fibers. Details on sector distribution of various products appear in table A-4 of Appendix A.

No sales from secondary agriculture to foreign trade or government appear in the transactions table, since all secondary products were assumed to undergo processing before entering either of these two sectors.

Secondary products used by households were handled as described above for primary products. Only consumption of farm-produced commodities in farm households was considered as a flow from secondary sectors to households.

ESTIMATING THE OUTPUT OF INDUSTRY SECTORS

Industry output estimates were derived from numerous sources. Output data of the producing sector, input data of the purchasing sector and various combinations of the two were used. Only the flows to agricultural sectors are described here in detail, since these were of primary interest in the study. Of the three farm product processing sectors—sectors 13, 14 and 15—only sector 13 was important in providing inputs to agriculture; sector 14 provided a few agricultural inputs, and sector 15 provided none.

SECTOR 13 PRODUCTS TO AGRICULTURAL SECTORS

The industries comprising sector 13 of the input-output model were primarily those engaged in processing food crops. Since many of the food grains and their by-products were also used as animal feeds, the sector was defined to include feed processing. The amount of sector 13 output going to agricultural sectors as inputs was estimated from farm feed consumption data (23). Most of the feeds went to secondary sectors 7 to 12, with only feeds for horses assessed as a cost to primary sectors.

Data on consumption of several classes of commercial feed were in physical terms, permitting estimates of total quantities of each class fed in each region in 1949. Formula feeds, consisting largely of carbohydrate ingredients which originate chiefly in region 2, were valued at region 2 producers' value prices (47, 1950). Where such prices were not available, prices paid by farmers for the kind of feed were adjusted, using a margin estimate from the 1947 Bureau of Labor Statistics study, to producers' value. Protein and mill feeds were valued F.O.B. the primary market for the respective feeds (46, 1950). Total value of these feeds consumed in agricultural sectors in 1949 was 1,962 million dollars, the sum of the entries in row 12, columns 1 to 12, table 2.

SECTOR 14 PRODUCTS TO AGRICULTURAL SECTORS

These entries were negligible. They included a few supply items, such as bags going chiefly to cotton and tobacco producers in primary sectors and containers going to dairy producers in secondary sectors, according to the detailed data of the 1947 interindustry study (61). However, an important indirect product flow from sector 14 to secondary agriculture consisted of oil-meals, which were routed through sector 13 before delivery to farm sectors.

SECTOR 16 PRODUCTS TO AGRICULTURAL SECTORS

Products of sector 16 used as farm inputs were fuel and oil, repairs and repair services, tires and tubes, and replacement vehicles and machinery. Data sources were chiefly the 1950 Census of Agriculture (42), Agricultural Statistics (46) and the 1947 interindustry study (60 and 61). Purchasers' value of fuel and oil used in all agricultural sectors was available in census data and was adjusted to producers' value using the margin coefficient of the 1947 study (60). Regional differences in margins were not considered.

Purchasers' value of all farm machinery repairs was also available from census data (42), and was reduced to producers' value using margin data from the 1947 study (60). Value of repairs and services on farm cars and trucks was estimated from the 1947 transactions table (61) adjusted to 1949 conditions.

The inputs required by agriculture to maintain its 1949 stock of machinery were estimated as 10 percent of the 1949 value of agricultural machinery and equipment as given by Agricultural Statistics (46, 1952). This class of inputs offers the possibility of capital build-up, which was not treated in the model. For example, shipments of farm machinery in 1949 were 400 million

dollars greater than the 1,091 million dollars estimate of maintenance purchases made by the method explained above.

Total value of sector 16 products used by agricultural sectors in 1949 was estimated as 2,715 million dollars. Input entries for primary and secondary sectors computed from this total were the result of two assumptions: (1) production of the various commodities required the same relative machinery and fuel inputs in 1949 as in 1947, and (2) use of sector 16 products by primary and secondary agricultural sectors was proportional to the value of output of each commodity in the regions producing it.

Relative machinery and fuel inputs to each commodity group were estimated from 1947 data (61) as: meat animals and products, 8.5 percent; poultry and eggs, 2.4 percent; dairy, 6.4 percent; food grains and feed crops, 57.2 percent; cotton, 6.5 percent; tobacco, 1.2 percent; oil crops, 4.9 percent; vegetables and fruits, 12.9 percent.

Relative regional production of each of the respective commodities was estimated from farm output data for 1949 (36, tables 16 and 25). Combining the total sector 16 inputs to agriculture, each region's share of the value of production of each commodity and each commodity's share of total agricultural machinery and fuel inputs, resulted in the input totals shown in row 16, columns 1 to 12, table 2.

SECTOR 17 PRODUCTS TO AGRICULTURAL SECTORS

Products of sector 17 were primarily fertilizers, lime, chemicals and seeds for use by primary agriculture sectors, chemicals and drugs for secondary sectors, and similar products for industry and final demand sectors.

Physical quantities of fertilizer and lime used by primary sectors in 1949 were estimated for each region (46) and converted to producers' value using regional prices paid by farmers (45) adjusted by the marginal coefficient of the 1947 study (60). The value of spraying and dusting materials used by each primary sector was estimated in purchasers' value from (5) and adjusted to producers' value by use of the 1947 marginal coefficient. Census data (42) were adjusted by the 1947 marginal estimate to get producers' value of seeds, bulbs, trees and plants used by farmers in each region in 1949.

Drugs and medicines were the main products of sector 17 used by secondary agriculture. Values of these products used in 1949 by each secondary sector were estimated from 1947 data (61) according to (a) the relative use by secondary commodity sectors as shown in 1947 data and (b) the relative regional shares of production of these secondary commodities in 1949. Values of insecticides used on livestock in each region were obtained from (5).

SECTOR 18 PRODUCTS TO AGRICULTURAL SECTORS

No attempt was made to specifically identify the products of sector 18. They include all goods and services not accounted for in other sectors. Net output of sector 18 made up 68 percent of the net output of all industry sectors in 1949. Major products were those of

heavy industry, transportation and merchandising, with the latter two being the most important inputs to agricultural sectors. In the absence of detailed data for 1949, sector 18 inputs to agricultural sectors were estimated from 1947 commodity inputs as shown in the 1947 interindustry study (61). Commodity inputs were distributed to primary and secondary agricultural sectors according to relative sector shares in the total production of each commodity as detailed in (36).

SECTOR 19 AND SECTOR 20 PRODUCTS TO AGRICULTURAL SECTORS

No imported products were consigned directly to agriculture as inputs, even though imported products included grains and farm machinery. Imports were consigned, first, to industry sectors and, then, to their ultimate users. As a result, the trade row (row 19) in table 2 has zero entries in columns 1 to 12.

In the model described here, government is defined as an intermediate or producing sector (see Appendix B for alternative model). The product of the government sector in input-output analysis is government services. A measure of the services provided each person or each sector in an input-output model is the amount of taxes paid. This is the convention under which government output was estimated in this study for the model in which it was considered as a producing sector. (In the other model, government is part of the final demand sector. Inputs absorbed then become analogous to inputs taken by households and do not directly affect the interdependence coefficients for other sectors.)

Tax payments by agricultural sectors included farm real estate and personal property taxes, licenses, permits and motor vehicle taxes. Total real estate taxes were estimated for regions from (a) land in farms and (b) taxes paid per acre in 1949 (46—1952 and 1951, respectively). Secondary sectors were assessed real estate taxes for half the value of farm buildings in each region. Total personal property tax payments in 1949 were divided among primary and secondary sectors according to the relative values of machinery and livestock in each region. Combined motor vehicle and fuel tax payments were estimated as a national total and allocated to primary and secondary sectors using machinery cost data estimated in distributing the output of sector 16. Tax payments by industry sectors were based mostly on the 1947 study (61). The estimates are explained in (36) along with the estimates of personal taxes paid.

THE HOUSEHOLD ROW; RETURN FOR PERSONAL SERVICES

Household output entries in the transactions table are similar to row components of intermediate sectors. Both represent value of output of the row sector used by the column sector in its productive activity. Evaluation of labor inputs furnished to agriculture by households offered a difficult problem. Most farm work is done by farm operators, with less than one-fourth of the compensation received by farm workers in recent years having been in the form of wages. The balance of the wage payment to farm households appears in farmers' net income statements and includes not only labor income to farm operators but also interest on investment in the farm business, management returns and other

such items. Net farm income was available only as a national total, rather than by states or regions.

Since the entries in the household row were not intended to be used to compute input coefficients of the type shown in equation 3.1, or to estimate interdependence coefficients, they were of minor importance in this study. In the transactions matrix (table 2), the entries in the household row, columns 1 to 6, indicate the returns to farmers in each region for crop production. These entries were computed as a residual or balancing item and are equal to the difference between the value of the net output of a sector and the value of all inputs except those by households. The residuals do not differ greatly from the result of multiplying the hours spent in production times the wage rate. Thus, farmers in 1949 appear to have furnished labor, management and capital to primary agriculture for a return approximately equal to the market wage rate.

Entries in row 21, columns 7 to 12 represent the hours spent in secondary agricultural production in each region (16), valued at the regional market wage rate for 1949 (40). In this case, another entry in the secondary input columns was estimated as a residual (see explanations of primary agricultural sectors), and the procedure used to evaluate labor in primary sectors could not be used for secondary sectors. Also of interest are coefficients expressing the hours of labor in each agricultural sector per dollar of net output. These are shown in table A-5 of Appendix A, along with coefficients expressing the imputed value of labor per dollar of net output. The "time" coefficients for sectors 1 and 6 reflect the production of crops which are heavy labor users under present techniques. The 1.03 hours labor per dollar of net output in sector 3 (South) is an indication largely of cotton production techniques in 1949 and is a corollary of the low sector 16 coefficient (fuel and machinery) for sector 3.

Entries in the household row, table 2, columns 13 to 20 indicate returns to individuals in industry sectors. Details appear in (36).

TRANSACTIONS BETWEEN INDUSTRY SECTORS

As explained previously, most of the data for estimating the flows of goods between industry sectors in 1949 were obtained from the transactions table of the 1947 Bureau of Labor Statistics interindustry study (61). Explanations of the methods of adjustment of the data for changes in price level and for differences in concept between the earlier and the present study appear elsewhere (36) and are not repeated here.

EMPIRICAL RESULTS

The intersector flows estimated for 1949 are shown in table 2 (the transactions table or matrix). Entries there are the values of goods and services which moved between defined sectors of the United States economy in 1949 and are the empirical counterparts of equation 1.1. Although the entries in table 2 appear as parameters, a more useful interpretation is that they represent approximations of the intersector transactions in 1949. No further claim is made for the data.

TABLE 3. DIRECT PURCHASES PER DOLLAR OF OUTPUT BY ECONOMIC SECTORS, 1949.*

Sector number	Primary agricultural sectors						Secondary agricultural sectors					
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 1	Region 2 #	Region 3	Region 4	Region 5	Region 6
1	.....	.....	.....	.....	.....	.....	0.2890	.....	0.0011	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	0.0120	0.3807	0.0016	0.0001	0.0030	0.0064
3	.....	.....	.....	.....	.....	.....	.....	0.4042	.....	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	0.0002	0.0002	0.4632	0.0118	0.0110
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0001	0.4431	0.0001
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0001	0.2999
7	0.0730	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	0.0752	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	0.0352	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	0.0569	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	0.0788	.....	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	.....	0.0336	.....	.....	.....	.....	.....	.....
13	0.0021	0.0003	0.0030	0.0008	0.0001	0.0002	0.2378	0.0712	0.1629	0.0808	0.0570	0.1822
14	0.0005	0.0003	0.0017	0.0003	0.0001	0.0002	0.0015	0.0008	0.0010	0.0005	0.0005	0.0011
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	0.1235	0.1309	0.1043	0.1147	0.1448	0.1285	0.0283	0.0280	0.0275	0.0267	0.0262	0.0278
17	0.1272	0.0705	0.0923	0.0348	0.0365	0.0682	0.0028	0.0030	0.0035	0.0033	0.0032	0.0028
18	0.2167	0.2445	0.2220	0.2249	0.2608	0.2249	0.1622	0.1357	0.1442	0.1285	0.1217	0.1478
19†	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20†	0.0672	0.0622	0.0324	0.0471	0.0603	0.0616	0.0145	0.0131	0.0102	0.0135	0.0138	0.0133

* Each entry shows direct purchases from the industry named at left by the industry named at the top per dollar of output by the latter.
 † The foreign trade and government sectors are considered alternately in the text as (a) intermediate and (b) final demand sectors.

TABLE 3 (continued)

Sector number	Industry sectors							
	13 Crop food products	14 Nonfood crop products	15 Livestock products	16 Machinery and fuel	17 Miscellaneous supplies	18 All other products	19† Foreign trade	20† Government
1	0.0178	0.0046	.....	.....	0.0066	0.0001	0.0016	0.0012
2	0.0496	0.0537	.....	.....	0.0141	0.0015	0.0183	0.0061
3	0.0401	0.0960	.....	.....	0.0047	0.0005	0.0512	0.0059
4	0.0435	0.0445	.....	.....	0.0086	0.0007	0.0280	0.0128
5	0.0174	0.0033	.....	.....	0.0044	0.0000	0.0023	0.0035
6	0.0599	0.0154	.....	.....	0.0052	0.0001	0.0088	0.0032
7	.....	0.0001	0.0978	.....	.....	.....	.....	.....
8	.....	0.0013	0.3166	.....	.....	.....	.....	.....
9	.....	0.0002	0.0732	.....	.....	.....	.....	.....
10	.....	0.0031	0.1176	.....	.....	.....	.....	.....
11	.....	0.0028	0.0376	.....	.....	.....	.....	.....
12	.....	0.0009	0.0515	.....	.....	.....	.....	.....
13	.....	0.0178	0.0132	.....	0.0073	0.0123	0.0358	0.0087
14	0.0528	.....	0.0015	0.0175	0.0110	0.0371	0.0673	0.0043
15	0.0374	0.0324	.....	.....	0.0065	0.0127	0.0255	0.0145
16	0.0082	0.0041	0.0035	.....	0.0172	0.0425	0.2078	0.0163
17	0.0079	0.0114	0.0019	0.0174	.....	0.0145	0.0581	0.0025
18	0.1713	0.1721	0.0521	0.5191	0.3949	.....	0.6393	0.3252
19†	0.0862	0.0446	0.0077	0.0040	0.0151	0.0216	.....	0.0681
20†	0.0393	0.0756	0.0113	0.0563	0.0683	0.1501	0.0365	.....

Entries in each row of table 2 are the value of the output of the row sector which was used as an input by the sector identified in the column heading. The last entry in each row, the net output (X_i) is the sum of the previous entries in the respective row. Each column then, includes the entries describing the value, the source and to some extent, the nature of all commodities making up the inputs of the sector named in the column heading.

The array of inputs and outputs in the transactions matrix is convenient for computing coefficients expressing the relationship between the net output of a sector and the inputs provided by other sectors. These are the technical coefficients of production shown in equation 3.1. Each coefficient (a_{ij}) is the fraction of a dollar's worth of the output of a row sector (i) which is required as an input by a column sector (j), so that sector j may produce a dollar's worth of its product.

Coefficients in table 3 were computed as defined by equation 3.1, for the 20 sectors treated here as intermediate sectors, including foreign trade and government. For example, a_{17} (row 1, column 7) was computed as: $\$644.9/\$2,231.5 = 0.2890$. The sum of the entries in each column of table 3 is the fraction of a dollar's worth of nonlabor inputs required by the re-

spective column sector per dollar of its net output.

The ratios of table 3 form the matrix of coefficients of the equations describing the economy. These equations, the empirical counterpart of equation 5.1, express the final demand (y_i) for the products of any intermediate sector as a function of the flows of goods and services between intermediate sectors and the net outputs of intermediate sectors.

Computation of the inverse of the matrix of production coefficients (table 3) yields coefficients expressing the net outputs of any sector as a function of the parts of the final bill of goods (y_i) as in equation 6.1. These coefficients are shown in table 4 and are called interdependence coefficients in the terminology of interindustry studies. Each interdependence coefficient expresses a relationship between a portion of the final bill of goods and the net output of a sector (equation 6.1). For example, assume a change of \$1.00 in the y_1 portion of the final bill of goods from that shown in table 2 (\$92.6 million): The coefficients 1.0239, 0.0099, 0.0076, . . . 0.1653 in column 1, table 4, indicate the change which would be necessary in the net outputs of sectors 1, 2, 3, . . . 20 to provide the product flows required by all sectors so that sector 1 may supply the larger final bill of goods.

TABLE 4. INTERDEPENDENCE COEFFICIENTS BETWEEN THE FINAL BILL OF GOODS AND NET OUTPUTS FOR 1949. COMPUTED FROM 20TH ORDER INPUT COEFFICIENT MATRIX.*

Sector number	Primary agriculture sectors						Secondary agriculture sectors					
	1	2	3	4	5	6	7	8	9	10	11	12
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
1	1.0239	0.0016	0.0017	0.0012	0.0013	0.0015	0.3013	0.0025	0.0056	0.0026	0.0021	0.0047
2	0.0099	1.0365	0.0068	0.0055	0.0067	0.0068	0.0336	0.4014	0.0174	0.0100	0.0118	0.0232
3	0.0076	0.0063	1.0202	0.0051	0.0060	0.0059	0.0184	0.0085	0.4239	0.0089	0.0079	0.0146
4	0.0079	0.0064	0.0058	1.0321	0.0070	0.0064	0.0184	0.0086	0.0139	0.4846	0.0203	0.0258
5	0.0022	0.0016	0.0016	0.0012	1.0376	0.0015	0.0061	0.0025	0.0044	0.0027	0.4613	0.0048
6	0.0041	0.0028	0.0028	0.0022	0.0025	1.0128	0.0176	0.0064	0.0125	0.0070	0.0056	0.3165
7	0.0760	0.0012	0.0011	0.0010	0.0011	0.0011	1.0240	0.0013	0.0020	0.0013	0.0012	0.0020
8	0.0046	0.0814	0.0035	0.0033	0.0039	0.0037	0.0090	1.0338	0.0064	0.0045	0.0044	0.0070
9	0.0012	0.0010	0.0366	0.0008	0.0010	0.0009	0.0021	0.0011	1.0161	0.0012	0.0011	0.0017
10	0.0019	0.0017	0.0015	0.0598	0.0017	0.0016	0.0035	0.0019	0.0028	1.0290	0.0025	0.0035
11	0.0007	0.0006	0.0005	0.0005	0.0822	0.0006	0.0013	0.0007	0.0010	0.0007	1.0368	0.0011
12	0.0008	0.0007	0.0006	0.0006	0.0007	0.0346	0.0017	0.0008	0.0013	0.0009	0.0008	1.0115
13	0.0309	0.0161	0.0178	0.0140	0.0149	0.0158	0.2557	0.0823	0.1770	0.0922	0.0682	0.1945
14	0.0267	0.0249	0.0233	0.0210	0.0248	0.0228	0.0386	0.0245	0.0325	0.0249	0.0242	0.0322
15	0.0121	0.0108	0.0095	0.0089	0.0106	0.0099	0.0202	0.0114	0.0161	0.0018	0.0111	0.0165
16	0.1640	0.1696	0.1357	0.1463	0.1845	0.1608	0.1127	0.1104	0.1094	0.1127	0.1258	0.1076
17	0.1448	0.0866	0.1056	0.0475	0.0321	0.0817	0.0615	0.0437	0.0584	0.0333	0.0338	0.0413
18	0.4674	0.4659	0.4076	0.3991	0.4768	0.4243	0.4264	0.3928	0.4310	0.3956	0.4093	0.4138
19†	0.0281	0.0252	0.0213	0.0206	0.0248	0.0234	0.0445	0.0256	0.0352	0.0263	0.0251	0.0364
20†	0.1653	0.1554	0.1140	0.1247	0.1540	0.1457	0.1351	0.1143	0.1132	0.1131	0.1211	0.1195

* The interdependence coefficients in each column show the amount of net output of the sector at the left which is associated with one dollar of final demand for products of the column sector.

† Foreign trade and government are considered as intermediate sectors in this model.

TABLE 4 (continued).

Sector number	13 Industry sectors		15	16	17	18	19†	20†
	Crop food products	Nonfood crop products	Live-stock products	Machinery and fuel	Miscellaneous supplies	All other products	Foreign trade	Government
	1	0.0211	0.0073	0.0318	0.0014	0.0083	0.0018	0.0059	0.0029
2	0.0675	0.0681	0.1366	0.0081	0.0230	0.0106	0.0404	0.0158
3	0.0581	0.1076	0.0399	0.0087	0.0133	0.0103	0.0726	0.0162
4	0.0582	0.0573	0.0666	0.0075	0.0165	0.0092	0.0463	0.0214
5	0.0207	0.0072	0.0201	0.0015	0.0063	0.0019	0.0064	0.0053
6	0.0655	0.0204	0.0233	0.0028	0.0085	0.0036	0.0171	0.0067
7	0.0066	0.0050	0.1013	0.0014	0.0025	0.0022	0.0053	0.0028
8	0.0215	0.0204	0.3307	0.0050	0.0078	0.0075	0.0190	0.0095
9	0.0058	0.0072	0.0755	0.0013	0.0019	0.0019	0.0062	0.0025
10	0.0096	0.0016	0.1229	0.0022	0.0033	0.0031	0.0089	0.0044
11	0.0038	0.0051	0.0398	0.0008	0.0013	0.0011	0.0027	0.0015
12	0.0049	0.0039	0.0529	0.0008	0.0013	0.0012	0.0033	0.0016
13	1.0195	0.0342	0.1028	0.0131	0.0201	0.0206	0.0612	0.0222
14	0.0810	1.0243	0.0261	0.0463	0.0372	0.0492	0.1194	0.0312
15	0.0517	0.0441	1.0120	0.0137	0.0190	0.0210	0.0500	0.0261
16	0.0914	0.0725	0.0890	1.0419	0.0623	0.0668	0.2919	0.0662
17	0.0443	0.0431	0.0364	0.0326	1.0178	0.0242	0.0970	0.0210
18	0.4487	0.4056	0.3677	0.6481	0.5457	1.1565	1.0222	0.4824
19†	0.1123	0.0698	0.0341	0.0332	0.0422	0.0425	1.0518	0.0886
20†	0.1426	0.1631	0.1086	0.1652	0.1647	0.1875	0.2364	1.0881

USES OF DATA AND COEFFICIENTS

Interindustry analysis is peculiarly historical in that it attempts to ascertain the relationships among sectors of the economy in some past period as an aid in understanding the effects of future disturbances. The usefulness of input-output analysis for projection is limited (a) by data accuracy, (b) by the difficulty of knowing what future changes or disturbances are in prospect and (c) by lack of ability to allow changes in *mixes*, depending on income elasticities of demand. While little information is available about (a), considerable effort has been spent in estimating (b)—the prospective changes in the economy. Two likely changes which will affect agricultural output are population change, both in number and composition, and changes in consumption habits resulting from changes in income. These are subsequently discussed in relation to the model.

THE INPUT COEFFICIENT MATRIX

Two types of interpretations can be applied to the input and interdependence coefficients of an input-output analysis. First, as is the general convention in input-output literature, the coefficients may be considered as expressing the increase in output of one producing sec-

tor which is associated with a change in output of another producing sector or with a change in final demand for particular sectors. The second interpretation is more descriptive; namely, the coefficients express the amount of output of one sector used in 1949 per dollar of output or per dollar of final demand for products of other sectors. The interpretations used in this study are in the descriptive vein. Although the terminology employed is in conventional terms of *change*, the magnitudes of change are considered to be extremely small.

Estimates of changes in the net output of various industry sectors per dollar of change in net output of agricultural sectors can be made using the coefficients of table 3. Entries in any column of table 3 indicate the change in net output required in each row sector to supply the column sector with enough inputs to increase its output by \$1.00. It is implied that the increased output of all sectors would include all the products of the sector in their historical (or fixed mix) proportions. Reasons for possible deviation from this situation are discussed later.

A \$1.00 net output of each primary sector (sectors 1 to 6) used only negligible amounts of sector 13 net outputs (columns 1 to 6, row 13) in 1949. These coefficients reflect the small quantities of manufactured

feeds consumed by horses in each agricultural region in 1949.

Similar estimates of sector 13 products needed per dollar of net output of each secondary agricultural sector may be made from table 3 coefficients. The entries in row 13, columns 7 to 12, table 3 show wide differences in the dependence by secondary agricultural sectors upon the feed industry. The two major grain-deficit regions, the Northeast and the Far West (sectors 7 and 12, respectively), used relatively large quantities of sector 13 products per dollar of output of livestock products. Data in table A-4 of Appendix A suggest tentative explanations for the sector differences. For example, the secondary commodity output of sectors 7 and 12 is made up largely of milk and poultry (table A-4), both of which require relatively large amounts of high-protein feeds, one of the products of sector 13. Also, both are grain-deficit regions. They import grain directly to farms and through the manufactured feeds of sector 13.

Sector 16 provides a large volume of agricultural inputs as described earlier. Data of table 3 indicate that each \$1.00 in net output by sectors 1 to 6 used 12, 13, 10, 11, 14 and 13 cents, respectively, of output from sector 16. Again these estimates, are quantitative examples of differences in production methods between geographic regions. Sector 3, the Southeast, purchases relatively smaller quantities of machinery and fuel inputs per \$1.00 unit of output than do other primary sectors. This is true because such a large portion of the primary agricultural output in the Southeast is produced on tobacco and cotton farms where few machines are used. (See table A-5 in Appendix A for the associated labor coefficient.) Regions 4 and 5, both relying heavily on small grains for crop output, use relatively large machinery and fuel inputs per dollar of primary output because of low crop yields per acre and the spread of machine operations over many acres to produce a specified crop output. A current example of the interdependence of sector 16 and crop sectors is of particular interest. The most recently adopted farm program, the Soil Bank, features payments to farmers for retiring land from production. But when land is retired, other inputs are left unused on the farm or are never purchased. Important among these inputs are those provided by sector 16. In sector 2, for example, it may be seen (table 3) that each potential dollar's worth of corn not produced reduces sector 16 net output by about 13 cents. Total contraction of farm and nonfarm sectors of the economy, on a national or local basis, may be effectively studied in an input-output framework.

Coefficients in row 16, columns 7 to 12, table 3, indicate the relatively minor importance of machine inputs in livestock as compared with crop production. The coefficients are similar in all regions; a dollar of livestock output in each region used about 2.8 cents of inputs from the fuel-machinery sector. Coefficients in row 17, columns 1 to 6, table 3 are also descriptive of important regional differences in production techniques. Sectors 1 and 3, for example, are heavy users of fertilizers from sector 17 per dollar of crop output, while range areas (sectors 4 and 5) use little fertilizer but some insecticides (36).

Other coefficients of particular interest are those of row 18, columns 7 to 12, table 3, expressing the relation-

ship of a diverse group of sector 18 products, chiefly transportation and services, to secondary agricultural production. Since sectors 7 and 12, the Northeast and Far West, respectively, import large amounts of concentrate feeds both directly and through sector 13 of this model, they also absorb relatively large amounts of the trade and transportation margins attached to the feeds. (The coefficients show the trade-transportation inputs per dollar of output in column sectors.) This point is illustrated in table 3 by the relatively large coefficients in columns 7 and 12, compared with columns 8 to 11, row 18. Not only do the Northeast and Far West use large amounts of protein feeds relative to grain, but they also are farther than other feed-importing regions from supplying areas. Both of these factors add to the relatively large amount of trade and transportation inputs used per dollar of secondary output in the Northeast and Far West.

Little importance is attached to the coefficients of table 3 expressing the relationships between net output of each secondary agricultural sector and the inputs provided to it by the primary sector in the same region (row 1, column 7, row 2, column 8, etc.). These primary to secondary flows were valued as a residual (see earlier explanation) rather than at market prices. However, the coefficients of table 3 correctly reflect the lesser importance of crop production in the Northeast and Far West with respect to livestock production in the same region, compared with other regions. Also, data in table A-1 give intraregional commodity flows for major feed crops in 1949. Net outputs of sectors 7 and 12 relative to sector 8 (table 2) are large compared with "home-grown" inputs used by sectors 7 and 12 relative to those used by sector 8 (table A-1).

Numerous estimates of direct relationships between sectors may be made from table 3. For example, the sums of the *industry* coefficients for the primary agricultural sectors or columns (i.e., the sum of rows 13 through 18 for columns 1 through 6) show the direct purchases from all industry sectors per dollar of crop output. They quantify a well-known situation in farm production, the importance of cash outlay for agricultural inputs. The magnitudes of these coefficients are a function of crops grown, prices received, yields obtained and inputs used. The total of industrial inputs for crops averages approximately 43 cents per dollar of primary output. It is lowest in the Great Plains (column 4) where little fertilizer (sector 17) is used per acre or per dollar of output and because such a large proportion of the area is in native grasses not requiring cultivation. The figure is relatively low for the Southeast (column 3). While large amounts of fertilizer and insecticides (sector 17) are used per acre, relatively few sector 16 inputs are used, resulting in the low aggregate coefficient.

The sum of industry coefficients is high in the Corn Belt (column 2) because, in contrast to the Great Plains, most of the forage acres require cultivation and fertilizer. Also, in contrast to the Southeast, the per-acre value of crops does not compare favorably with cotton, tobacco and fruits.

For secondary agricultural production (columns 7-12), total industrial input coefficients are greatest for the Northeast (column 7) where dairying and poultry are most important. It is also high in the Southeast

(column 9) and the Far West (column 12) where these same two enterprises represent relatively large portions of the total secondary output. It is lowest in the range regions (column 5) since range cattle and sheep require small quantities of purchased industrial products per dollar of livestock output.

INTERDEPENDENCE BETWEEN AGRICULTURAL REGIONS

One of the objectives of the study, to estimate interdependence coefficients between agricultural regions, was largely abandoned because of data shortages. Neither interprimary nor intersecondary flows and only minor interregional primary to secondary sector transactions could be measured. It is seen in table 3 that the largest direct interregional effect of increased secondary production upon a primary sector is that upon sector 2 (Corn Belt), induced by output of sector 7 (Northeast). This is related to the previous discussion of small *intra-sector* flows in the Northeast. The coefficient (0.012) is deceptively small, because the model accounts only for the interregional feed flows required to make up the deficit of grain to be fed after minor processing on sector 7 farms.

A further indication of the dependence of sector 7 upon grain-surplus sector 2 is given by observation of two input coefficients in table 3. The coefficient in row 2, column 13 (0.050) reflects in part, feed-grain flows to sector 13 from the Corn Belt. The coefficient in row 13, column 7 (0.238), shows the relative importance of the feed-industry component of sector 13 to livestock production in the Northeast. Thus, sector 7 is related more closely to sector 2 than appears to be the case by inspection of a single direct input coefficient. Similar joint comparisons are possible for other sectors.

INTERDEPENDENCE COEFFICIENTS

As mentioned earlier, interdependence coefficients might be considered to (a) reflect changes in output of one sector associated with changes in final demand for other sectors or (b) describe the amount of output of one sector used per dollar of final demand in other sectors in 1949. While some of the examples used are in terms of *change*, the interpretation of the authors is of a descriptive vein as in procedure (b). As noted earlier, the interdependence coefficients (table 4) show the dollar's worth of product of the row sector associated with a dollar's worth of final goods of the column sector. Thus, for example, the coefficients in column 7, table 4, indicate that sectors 1, 2, 3 . . . 18 would have to provide products valued at \$0.30, \$0.03, \$0.02, . . . \$0.46, in order to enable sector 7 to furnish an additional dollar's worth of final goods.

Little information can be gained from postulating changes in the final bill of goods for agricultural sectors. This is because final demand for products of each agricultural sector is*defined to include only home-used farm products. Given the model employed, the important changes in final demand affecting farm sectors are changes in the demand for the products of industries processing the products of agricultural sectors. Because of the linear nature of the model, postulated changes in demand for the products of a particular sector suppose that the products of the sector will be forthcoming in the proportions represented at the time of measurement for the model. Also, a given increase in the final demand for a particular sector calls for output from producing sectors in the same ratio that output was forthcoming from the various sectors at the historic point of time to which measurements refer. *This restriction of a linear model should be clearly recognized in interpretations of the interdependence coefficients.* It is the reason that the descriptive interpretation is included in this study.

RELATION OF SECTOR 13 TO AGRICULTURAL SECTORS

Products of sector 13 entering the final bill of goods include food products ranging from fresh fruits consumed with a minimum of processing, to bakery products whose forms are changed many times. These products and the value of each going from given regions to sector 13 in 1949 are given in Appendix A, table A-2. Data there suggest explanations of relative sizes of coefficients in rows 1 to 6, column 13, table 4. Sectors 1 and 5, for example, produce only one-third the value of sector 13 inputs produced by sectors 2 and 6. This, in turn, results in small effects upon sectors 1 and 6 per dollar change in final demand for sector 13 products.

Table 5 gives, under the restrictions mentioned earlier, the effects upon the net outputs of certain agriculture and industry sectors, of a 10-percent change in household consumption of sector 13 products. The entries were derived as shown in the footnote to table 5. The arbitrary 10-percent projection in the sector 13 final bill of goods is not a prediction of demand changes. It is used only as a basis for comparing relative differences for the primary agricultural sectors which feed products into sector 13. Similarly, the absolute changes for agricultural sectors are not to be looked upon as demand predictions resulting from such *disturbances* as a growth in national product (since the *mix* would then also change) but as a way of presenting the relative crop sector flows to sector 13.

It is seen that either increases or decreases in the demand for processed primary food products would have

TABLE 5. ABSOLUTE AND PERCENTAGE CHANGES (PLUS OR MINUS) IN NET OUTPUTS OF PRIMARY AGRICULTURE AND INDUSTRY SECTORS AS A RESULT OF A 10-PERCENT CHANGE IN THE SECTOR 13 FINAL BILL OF GOODS.*

Primary agriculture sector	Absolute change in net output (000)	Percent change in net output	Industry sector	Absolute change in net output (000)	Percent change in net output
1	\$29,197	2.2	14	\$112,028	0.8
2	\$93,320	1.7	15	\$ 71,466	0.4
3	\$80,333	1.9	16	\$126,413	0.4
4	\$80,531	2.0	17	\$ 61,228	0.9
5	\$28,648	2.7	18	\$620,844	0.3
6	\$90,684	4.4	---	-----	---

*Absolute changes in net outputs were computed by multiplying 10 percent of the household entry in row 13, column 21, table 2 (\$1,383.5 million) by the interdependence coefficients in the respective rows, column 13, table 4. For example: \$1,383.5 million x 0.0211 = \$29.2 million or 2.2 percent of the 1949 net output of sector 1.

a smaller absolute effect but a larger relative effect upon most agricultural sectors than upon industry sectors. Also, the absolute change required in the products of sector 18 as a result of a 10-percent change in the quantity of sector 13 products consumed in households, would be greater than the sum of the changes required in all primary agricultural sectors. This fact points up, in numerical terms, the current situation with respect to the farmer's share of the consumer's dollar. The sum of the coefficients, 0.291, in lines 1 to 6, column 13, table 4 indicates that each dollar change in household consumption of sector 13 products requires only a 29-cent change in output by all primary agricultural sectors. The entry in line 18, column 13, table 4, (0.449) indicates that each dollar change in consumption of sector 13 food products requires a 45-cent change in the net output of sector 18, mostly in transportation and merchandising services. In line with income and price elasticities of demand and supply structures, the "food bundle" moving into final demand is made up, in value terms, of nearly twice the value of services from sector 18 as value of goods from the farm sectors.

Differences in relative changes for the six agricultural sectors in table 5 stem from the types of crop products produced. The percent change is greatest for region 6 (the West) because a large part of the crops represented are fruits and vegetables which are not processed through livestock. The percentage change is smallest for region 2 (the Corn Belt) despite the large coefficient. Large fractions of major Corn Belt crops move directly to livestock sectors rather than to processing sector 13 for which the 10-percent increase in final bill of goods has been projected. The percentage change also is small for region 3 (the Southeast) where tobacco, cotton and similar products do not move through food processing industries.

The figures presented represent interindustry relationships for a point in time; namely, 1949. They suppose a fixed mix in the product forthcoming with increases in final bill of goods. An increase in the demand for food products is not likely to result solely from an increase in population, leaving each part of the country a slightly enlarged model of today with respect to income, tastes and relative demands. Other prospective changes over time include (a) the level and (b) the distribution of income. Estimates of income elasticities of demand for food indicate that changes in either (a) or (b) above would have implications for the food product mix consumed by households. Therefore the input-output projections cannot be used realistically to indicate relative expansion needed by agricultural regions as national income grows.

Coefficients in column 14, table 4, indicate required changes in output of respective sectors per dollar change in final demand for products of sector 14. These products were tobacco, fibers, vegetable oils and others. Cotton and tobacco produced in region 3 are the important products. Each dollar of final demand for products of sector 14 involves a 10-cent increment of net output in the South (sector 3). Other crop sectors are less closely related to sector 14 final demand; with the Corn Belt, which supplies raw materials for vegetable oils, ranking next to sector 3. The coefficients in column 15, table 4 indicate dollar changes in sector net outputs per dollar change in sector 15 final demand. They also provide the basis for estimating effects on secondary and primary agricultural production of proportional changes in the final demand for the products of sector 15. These are chiefly meats and other livestock products.

The estimates appear in table 6. (Again, the 10-percent change is arbitrary. As mentioned previously, it is used to indicate relative relationships of an industrial sector with agricultural sectors.) A 10-percent change in consumption of sector 15 products requires relatively large changes in net outputs of both primary and secondary agriculture. In absolute terms, the changes induced in net outputs of other industrial sectors by sector 15 changes are sizable but are not so important as in the case of changes in sector 13. Also the coefficient indicating the change in sector 18 products per dollar change in sector 15 final demand is relatively small (0.368) compared with the sum of the coefficients of the secondary sectors (0.724). The latter sum indicates the aggregate change in net output required in secondary agriculture for each dollar increase in final demand for processed secondary agricultural products. Both this figure (0.724) and the parallel sum quoted earlier for primary agriculture (0.291), check roughly with recent estimates of the farmer's share of the consumer's dollar spent for primary and secondary products (46). The size of the figures (0.724 and 0.291, respectively) for secondary and primary products of agriculture indicates the relative amount of the consumer's dollar absorbed by transportation, processing and merchandising for products of the two sectors. It is larger for primary products (and the 0.291 portion going to the farm sector is smaller) because of the large amount of labor and capital services involved in milling, baking, packaging and retailing such products as grains.

Data in column 15, table 2 and coefficients in column 15, table 4 show the extreme importance of the

TABLE 6. ABSOLUTE AND PERCENTAGE CHANGES (PLUS OR MINUS) IN NET OUTPUTS OF AGRICULTURE AND INDUSTRY SECTORS AS A RESULT OF A 10-PERCENT CHANGE IN THE SECTOR 15 FINAL BILL OF GOODS.*

Primary agriculture sector	Absolute change in net output (000)	Percent change in net output	Secondary agriculture sector	Absolute change in net output (000)	Percent change in net output
1	\$ 49,881	3.9	7	\$159,065	7.1
2	\$214,496	3.7	8	\$519,404	7.0
3	\$ 62,660	1.5	9	\$118,620	5.2
4	\$104,631	2.5	10	\$192,999	6.4
5	\$ 31,638	2.9	11	\$ 62,445	6.6
6	\$ 36,630	1.8	12	\$ 83,152	6.9
Industry sector			Industry sector		
13	\$161,485	0.8	17	\$ 57,136	0.9
14	\$ 40,948	0.3	18	\$577,522	0.3
16	\$139,853	0.5	....	.....	....

*Estimated by using the coefficients of table 4 and the household final demand and net outputs of table 2.

Corn Belt in providing livestock and livestock products. Each 1 dollar's worth of sector 15 final demand products is associated with 33 cents worth of a diverse mixture of Corn Belt livestock products. Too, the coefficient (0.331) relating final demand for livestock products to direct sector 8 output is associated with the coefficient (0.137) in line 2, column 15, table 4. The latter reflects feed flows to sector 8 as a function of final demand for livestock products. Crop production in the Corn Belt is seen to be more closely related to final demand for livestock products than even direct livestock production in any other sector.

Crop production in other primary sectors is also sensitive to the level of final demand for livestock products as shown in column 15, table 4. Only the Great Plains region approaches the Corn Belt in this regard.

Even though sector 16 provides major inputs to agriculture, its products largely reflect the demand for motor vehicles and fuel for personal use. Only about 10 percent of sector 16 net output consisted of agricultural inputs in 1949, while half went to final demand. Large increases in personal consumption of sector 16 products have occurred in recent years and are expected to continue. The values of the coefficients in column 16, rows 1 to 12, table 4, confirm an obvious hypothesis—namely, that increased personal use of motor vehicles and fuel would have a minor effect upon the net outputs of agricultural sectors. On the other hand, final demand for farm products has considerable importance to sector 16 output. Dollar outputs by sector 16 per dollar of final demand in sectors 1, 2, 3 . . . 12 are indicated by coefficients in row 16, columns 1 to 12, table 4.

Similar conditions hold for changes in the consumption of final goods produced by sector 18. Sector 18 products include the personal services implicit in most goods as well as most of the durable commodities implicit in a high standard of living. This sector is sensitive either to a boom or to a depression, and its relationship to agriculture is of particular interest. The coefficients of column 18, table 4, indicate negligible interdependence between agricultural net outputs and each dollar of sector 18 final demand. In 1949 each dollar of sector 18 final demand was associated with agricultural outputs ranging from 0.0011 for secondary output in the Intermountain States to 0.0106 for primary output in the Corn Belt. In contrast, final demands for agriculture were associated with sector 18 outputs in amounts ranging from 0.3928 in the case of secondary products in the Corn Belt to 0.4768 in the case of primary products in the Intermountain States.

Treatment of foreign trade and government as intermediate sectors is subject to criticisms noted earlier. Hence interpretation of resulting coefficients is limited to brief examples. Coefficients in table 4, row 19, indicate the importance of sectors 2, 3 and 4 in providing grains and cotton for export. Also, the small coefficients in rows 7 to 12, column 19 indicate the lack of importance of livestock products as export items.

Final demand for government "products" is the demand for governmental services reflected in personal tax payments. One of these services has been the purchase and storage by government of grains and cotton. These purchases are largely from sectors 2 and 4 for grain, and sector 3 for cotton. Coefficients in table 4, column 20 of these sectors indicate the relative importance of government purchase and storage programs to corn (sector 2), cotton (sector 3) and wheat (sector 4).

INTERTEMPORAL COMPARISONS

An original objective of this study was to construct an input-output table for 1929, similar to table 2 for 1949, and to make comparisons between the two periods. However, data problems of the type encountered in constructing the 1949 table were found to be much greater for an analysis of 1929 interrelationships between sectors. Data for 1949 on feeds, fertilizers and other inputs were available in much greater detail than for 1929. Neither raw data nor a detailed parent study, such as the 1947 interindustry study, were available for 1929. Output data, however, were found to be adequate for some simple comparisons of the value of agricultural production in the several geographic regions of the United States in 1929 and 1949.

Table 7 data indicate the percentage of United States crop output from the six agricultural regions in 1949 and 1929. In large part, the differences between 1929 and 1949 represent changes due to technology and crop acreage. However, changes in relative commodity prices also account for some of the difference between the two periods.

During the period 1929 to 1949, the relative contribution to the United States output of feed grains increased for region 2 (the Corn Belt) only. The percentage contribution of all other regions declined. The difference is mainly because of differentials in yield changes due to hybrid corn, a practice most widely used in the Corn Belt. The big percentage increase in oil crops also was in the Corn Belt as soybean acreages and yields expanded. A very large relative increase in oil

TABLE 7. RELATIVE VALUE OF PRODUCTION OF MAJOR COMMODITIES BY PRIMARY AGRICULTURE SECTORS AND RELATIVE AGGREGATE PRIMARY AGRICULTURE PRODUCTION, 1949 AND 1929.

Commodity	Year	Primary agriculture sectors					
		1	2	3	4	5	6
		(percent of total U. S. production)					
Food grains	1949	3.3	18.5	5.4	48.7	14.6	9.5
	1929	6.0	21.5	6.4	45.3	10.4	10.4
Feed grains	1949	3.5	63.0	12.0	17.7	1.9	1.9
	1929	4.4	52.6	15.8	23.0	2.2	2.0
Oil crops	1949	0.4	45.7	28.8	20.4	0.5	4.2
	1929	0.4	26.7	39.5	30.6	2.8	....
Cotton	1949	....	3.1	53.3	32.1	1.7	9.8
	1929	....	1.5	61.2	33.3	0.7	3.3
Tobacco	1949	8.0	24.0	68.0	....	....	....
	1929	11.1	30.3	58.6	....	....	....
All crops*	1949	6.7	33.7	22.6	21.0	5.2	10.8
	1929	10.0	30.0	25.0	20.6	5.0	9.4

*Value of pasture is not included.

TABLE 8. RELATIVE PRODUCTION OF MAJOR COMMODITIES BY SECONDARY AGRICULTURE SECTORS AND RELATIVE AGGREGATE SECONDARY AGRICULTURE PRODUCTION, 1949 AND 1929.

Commodity	Year	Secondary agricultural sectors					
		7	8	9	10	11	12
			(percent of total U. S. production)				
Cattle and calves	1949	5.3	36.1	9.9	30.9	10.6	7.2
	1929	6.9	38.3	6.8	31.2	10.1	6.7
Hogs	1949	2.6	67.2	13.0	13.8	1.7	1.7
	1929	3.2	59.5	9.5	23.8	2.2	1.8
Sheep and lambs	1949	1.5	29.4	5.0	20.3	30.5	13.8
	1929	2.9	27.0	5.6	15.2	31.3	18.0
All secondary products*	1949	13.4	43.6	13.4	17.2	5.3	7.1
	1929	13.1	44.9	10.1	19.7	5.8	6.4

*Includes poultry and dairy products.

crops also took place in region 6 (the West) as— cotton acreage shifted to this region from region 3 (the Southeast). Similar changes in contribution of the Far West to the United States output of cotton fiber took place for the same reason.

For the aggregate of all crops, relative contribution to United States output declined in region 1 (the Northeast) and region 3 (the Southeast). The main reasons for these relative declines are: shifts in crop acreages, a smaller yield gain from technical innovations and different weights or prices placed by consumers on the crops of the different regions. While interdependence coefficients have not been computed for 1929, differences between changes in interdependence coefficients from 1929 to 1949 for the different regions would be of the same order as the relative changes expressed at the bottom of table 7.

Comparisons similar to those in table 7 are shown for secondary agricultural products in table 8. Again, differences exist, subject to the limitations of relative price changes and the choice of atypical years.³

Changes in relative contribution of the various regions to United States output of all secondary agricultural products were not great between 1929 and 1949. However, important percentage changes did take place for individual livestock products going into the livestock mix of regions. The percentage contribution of hogs by region 8 (the Corn Belt) increased from 59.5 to 67.2 percent. An increase in livestock also took place for region 9 (the Southeast) along with an increased acreage of feed grains in the region. The percentage declined in region 10 (the Plains States) with an increase in output of wheat and a decline in feed grains. These changes in contribution to United States livestock output seem to be associated mainly with changes in contributions to feed grain output. Changes in relative contributions of the various regions to United States output of other meat animals were small between 1929 and 1949.

Had interdependence coefficients been computed for 1929, comparison of the magnitudes for the two years would show: The interdependence coefficients for sectors 8, 9 and 12 have increased slightly relative to those of 1929; they have decreased very slightly, in a relative sense, for regions 10 and 11. However, the relative changes between regions (in the proportion contributed to the United States livestock mix) would have been very small. Hence, the linear nature of the model, and the restrictions of *fixed proportions between regions in the livestock mix*, would not have been serious had increases in the final bill of goods for sector 15 been

³ The problems of atypical years is less serious for livestock than for crops because output of the former is less sensitive to variations in weather.

projected from 1929 interdependence coefficients to the 1949 point in time. More serious would have been the *fixed mix* conditions imposed on (a) the output within each livestock sector and (b) the output of livestock products relative to the flow of crop products and the services of industrial sectors.

This last point emphasizes an aspect of input-output analysis mentioned earlier; namely, input-output analysis is in one sense descriptive, rather than analytical. It permits description of relationships between sectors at a particular point in time. It is less appropriate as a tool for explaining these relationships or in predicting flows under economic growth. Thus, it appears more valuable as a starting point for studies of economic interrelationships than as a terminus.

LIMITATIONS

The major limitations of input-output studies have been mentioned in another study (36) and details need not be repeated here. Mainly, the input-output and interdependence coefficients must be used for descriptive purpose—denoting interrelationships between economic sectors, as an average, at a particular point in time. In this sense, the technical input-output coefficients show the amount of input from one industry which was used, on the average, per dollar of output of another industry or sector. These coefficients need not remain constant between sectors for large changes. Increases in secondary agricultural production would, if the *mix* remained constant, require increases in secondary output equal to the technical coefficients shown. However, a sizable increase in primary output might well require increases in industrial inputs (e.g., fertilizer) greater than those which prevailed at a previous point in time. However, if the primary output increase came from farms not using fertilizer, or resulted along with secular trends in techniques, the input-output coefficient need not be misleading.

Similarly, the interdependence coefficients should be looked upon as those prevailing, on the average, at a given point in time. In this sense they also are descriptive and do not allow long-term projections in respect to supply or production functions. While they provide, on the average and for a given point in time, indications of the output effect for producing sectors of changes in final demands, they force the restrictions of (a) linearity and (b) fixed mixes of inputs and outputs into projections. While it has been stated (36) that these restrictions may not prove limitational in long-term industrial projections, this case likely does not hold true for agriculture—mainly because income elasticities of demand differ considerably within individual livestock and crop sectors and for the products grown in different agricultural regions.

APPENDIX A

Data of tables A-1 through A-5 are supplementary to the highly aggregated data of table 2. These tables are representative of the detail implicit in each entry of table 2.

TABLE A-1. QUANTITIES OF MAJOR CROPS GROWN AND FED WITHIN REGIONS WITH MINOR PROCESSING, 1949 (000).

Commodity	Unit of measure (thousands)	Region					
		1	2	3	4	5	6
Corn	(bu.)	92,434	1,468,294	390,369	345,537	12,257	1,960
Oats	(bu.)	55,259	758,271	55,552	165,709	25,407	16,208
Barley	(bu.)	11,167	12,041	4,707	19,499	26,381	23,916
Grain sorghum	(bu.)	.....	481	998	33,979	3,749	1,548
Wheat	(bu.)	10,266	35,266	6,633	16,367	10,600	6,100
Rye	(bu.)	300	1,367	200	733	167	33
Buckwheat	(bu.)	2,107	798	224	64	.....	.....
Soybeans	(bu.)	372	1,538	525	71	.....	.....
Peanuts	(lbs.)	.....	.....	10,103	13,437	216	.....
Hay (all)	(tons)	13,961	34,516	10,962	16,335	10,048	9,861
Corn silage*	(tons)	363	3,536	3,382	3,261	1,031	121
Sorghum forage*	(tons)	.....	587	624	9,102	786	84
Pasture*	(tons)	8,195	49,124	38,302	44,489	21,438	18,254

*In tons hay equivalent (36).

TABLE A-2. VALUE OF PRODUCTS SOLD TO SECTOR 13 BY PRIMARY AGRICULTURE SECTORS, 1949 (MILLIONS).

Product	Primary sector					
	1	2	3	4	5	6
Wheat	\$ 23.6	\$173.5	\$ 13.7	\$513.2	\$160.5	\$ 86.9
Rye	*	0.4	*	0.6	*	*
Buckwheat	1.1	0.4	0.1	*	.....	.....
Rice	.....	.....	75.0	43.5	.....	31.4
Corn	.....	434.9	25.5	71.7	.....	.....
Oats	.....	50.2	.....	32.7	2.1	1.2
Barley	0.1	7.5	0.1	10.9	4.8	8.2
Grain sorghum	.....	0.1	0.1	19.6	1.6	1.4
Popcorn	.....	4.6	0.8	.....	.....	.....
Cowpeas	.....	0.2	1.3	1.4	.....	.....
Dry Beans	1.2	17.8	.....	4.6	25.1	25.0
Field Peas	.....	0.1	.....	0.1	1.9	3.3
Velvet Beans	.....	.....	8.1	.....	.....	.....
Mung Beans	.....	.....	.....	0.3	.....	.....
Peanuts	.....	.....	133.0	34.3	0.7	.....
Sugar Beets	.....	.....	15.9	10.3	52.1	31.0
Sugar cane	.....	.....	40.9	.....	.....	.....
Sorgo	.....	1.4	3.6	0.4	.....	.....
Mint	.....	5.5	.....	.....	.....	3.9
Potatoes	53.4	36.6	33.1	16.4	34.4	44.8
Sweet Potatoes	2.0	1.1	22.3	3.3	.....	1.4
Honey	3.8	14.1	8.1	3.2	2.8	3.4
Truck crops	160.0	132.8	186.8	51.8	38.1	432.8
Fruits and nuts	88.8	82.6	212.9	28.7	15.4	492.0
Maple products	5.3	1.2	.....	.....	.....	.....
Total†	\$346.4	\$964.9	\$781.2	\$846.9	\$339.5	\$1,166.6

* Entry less than \$50,000.

† May not check because of rounding.

TABLE A-3. VALUE OF PRODUCTS SOLD TO SECTOR 14 BY PRIMARY AGRICULTURE SECTORS, 1949 (MILLIONS).

Product	Primary sector					
	1	2	3	4	5	6
Wheat	\$ *	\$ *	\$ *	\$ 0.1	\$ *	\$ *
Rye	*	.....	*	0.6	*	*
Corn	.....	32.1	1.9	5.3	.....	.....
Barley	0.2	22.7	0.3	30.2	13.3	24.6
Grain sorghum	.....	0.1	*	4.9	0.4	0.3
Soybeans	2.3	384.3	34.7	7.7	.....	.....
Flaxseed	.....	51.6	.....	57.6	0.8	15.7
Cottonseed	.....	7.5	105.0	103.9	4.3	28.4
Peanuts	.....	.....	11.3	2.9	0.1	.....
Cotton	.....	36.5	621.4	374.1	24.3	113.7
Tobacco	47.7	174.1	492.3	0.1	.....	.....
Hops	.....	.....	.....	.....	0.6	21.0
Total†	\$60.2	\$708.9	\$1,266.9	\$587.5	\$43.8	\$203.7

* Entry less than \$50,000.

† May not check because of rounding.

TABLE A-4. VALUES OF EACH SECONDARY PRODUCT SOLD TO SECTOR 15 BY EACH SECONDARY AGRICULTURE SECTOR, AND TOTAL VALUE OF SALES BY EACH SECONDARY SECTOR, 1949 (MILLIONS).

Product	Secondary sector					
	7	8	9	10	11	12
Cattle and calves	\$ 195.8	\$1,364.5	\$ 381.9	\$1,176.8	\$405.8	\$ 273.8
Hogs	69.9	2,324.0	283.5	436.0	53.8	57.3
Sheep and lambs	3.7	77.4	13.1	53.3	78.3	33.8
Dairy products	947.6	1,604.5	373.8	343.2	123.5	385.1
Poultry and products	769.7	1,062.4	435.8	380.1	103.4	296.5
Total*	\$1,986.7	\$6,432.8	\$1,488.1	\$2,389.5	\$764.9	\$1,046.8

* May not check because of rounding.

TABLE A-5. VALUE OF LABOR AND HOURS OF LABOR REQUIRED PER DOLLAR'S WORTH OF NET OUTPUT OF AGRICULTURE SECTORS, 1949.*

	Primary agriculture sectors					
	1	2	3	4	5	6
Value of labor per dollar net output	\$0.39	\$0.42	\$0.51	\$0.52	\$0.42	\$0.48
Hours of labor per dollar net output	0.56	0.46	1.03	0.45	0.52	0.67
	Secondary agriculture sectors					
	7	8	9	10	11	12
Value of labor per dollar net output	\$0.25	\$0.37	\$0.24	\$0.28	\$0.32	\$0.31
Hours of labor per dollar net output	0.31	0.44	0.53	0.37	0.37	0.33

*Includes direct and maintenance labor and time spent in business and management work on farms.

APPENDIX B

Sectors 19 and 20 were treated as intermediate or producing sectors in the preceding analysis. However, no firm theoretical or practical basis exists for doing so. Consequently, the interdependence coefficients for the alternative 18-equation model are presented here as table B-1. Data for computation of the coefficients of table B-1 are found in tables 2 and 3. Sectors 19, 20 and 21 of table 2 are now considered as final demand sectors; previously, only sector 21 was so considered. Thus, in table 3 the entries in rows (and columns) 1 to 18 are the coefficients of the system of 18 equations describing defined final demand quantities (y_i) as functions of net outputs of all sectors (X_i), as in equation 5.1.

The inverse of the coefficients of this new system of equations appears as table B-1. Like the coefficients in table 8, those in table B-1 express net outputs (X_i) as

a function of parts of the final bill of goods, in the manner of equation 6.1.

The 18-equation and 20-equation models are alternative ways of describing a given economy. Comparison of tables 2 and B-1 shows that the interrelationships estimated using the two models are similar. Thus, estimates of effects of arbitrarily assumed changes in final demand are also similar for the two systems. A minor difference results from the inclusion of three sectors—foreign trade (exports), government and households—in the final demand sector. In the 18-equation model the assumption of a \$1.00 change in final demand may involve many combinations of changes in the three final demand components. But whatever the sector of origin of the demand, the linear model requires that the whole product mix of the supplying sector be included.

TABLE B-1. INTERDEPENDENCE COEFFICIENTS BETWEEN THE FINAL BILL OF GOODS AND NET OUTPUTS FOR 1949. COMPUTED FROM 18TH ORDER INPUT COEFFICIENT MATRIX.*

Sector number	Primary agriculture sectors						Secondary agriculture sectors					
	1	2	3	4	5	6	7	8	9	10	11	12
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
1	1.0233	0.0011	0.0013	0.0008	0.0008	0.0010	0.3008	0.0021	0.0052	0.0022	0.0017	0.0042
2	0.0070	1.0338	0.0047	0.0033	0.0043	0.0305	0.3992	0.3992	0.0148	0.0077	0.0095	0.0205
3	0.0042	0.0031	0.0177	0.0026	0.0029	0.0029	0.0142	0.0057	0.4205	0.0061	0.0050	0.0110
4	0.0041	0.0029	0.0031	1.0293	0.0035	0.0030	0.0144	0.0057	0.0106	0.4817	0.0173	0.0224
5	0.0014	0.0008	0.0009	0.0006	0.0068	0.0008	0.0052	0.0019	0.0037	0.0021	0.4607	0.0041
6	0.0028	0.0016	0.0019	0.0013	0.0014	1.0117	0.0163	0.0055	0.0114	0.0060	0.0046	0.3153
7	0.0755	0.0007	0.0007	0.0006	0.0007	0.0007	1.0235	0.0009	0.0016	0.0010	0.0009	0.0015
8	0.0029	0.0798	0.0023	0.0020	0.0023	0.0022	0.0072	1.0326	0.0050	0.0033	0.0031	0.0055
9	0.0007	0.0006	0.0363	0.0005	0.0006	0.0005	0.0016	0.0008	1.0157	0.0008	0.0074	0.0013
10	0.0012	0.0010	0.0010	0.0592	0.0010	0.0009	0.0027	0.0013	0.0021	1.0284	0.0019	0.0028
11	0.0004	0.0036	0.0036	0.0002	0.0820	0.0003	0.0011	0.0005	0.0008	0.0005	1.0366	0.0009
12	0.0005	0.0004	0.0004	0.0003	0.0004	0.0343	0.0014	0.0006	0.0010	0.0007	0.0006	1.0113
13	0.0268	0.0122	0.0148	0.0109	0.0111	0.0122	0.2512	0.0791	0.1733	0.0890	0.0649	0.1906
14	0.0203	0.0190	0.0187	0.0162	0.0190	0.0173	0.0311	0.0195	0.0264	0.0198	0.0190	0.0259
15	0.0074	0.0065	0.0062	0.0055	0.0064	0.0060	0.0155	0.0080	0.0122	0.0083	0.0076	0.0125
16	0.1500	0.1567	0.1255	0.1359	0.1718	0.1489	0.0955	0.0991	0.0956	0.1012	0.1143	0.0931
17	0.1402	0.0824	0.1023	0.0442	0.0481	0.0779	0.0359	0.0400	0.0539	0.0296	0.0301	0.0366
18	0.3811	0.3858	0.3463	0.3345	0.3977	0.3495	0.3727	0.3276	0.3578	0.3302	0.3420	0.3371

* The interdependence coefficients in each column show the amount of net output of sector at the left which is associated with \$1.00 of final demand for products of the column sector. Foreign trade and government are considered as autonomous.

TABLE B-1 (continued)

Sector number	Industry sectors					
	13	14	15	16	17	18
	Crop food products	Nonfood crop products	Live-stock products	Machinery and fuel	Miscellaneous supplies	All other products
1	0.0202	0.0066	0.0313	0.0008	0.0077	0.0011
2	0.0618	0.0637	0.1341	0.0051	0.0196	0.0069
3	0.0492	0.1014	0.0366	0.0049	0.0089	0.0057
4	0.0514	0.0518	0.0635	0.0034	0.0121	0.0045
5	0.0195	0.0061	0.0195	0.0006	0.0053	0.0009
6	0.0631	0.0186	0.0223	0.0015	0.0070	0.0020
7	0.0058	0.0043	0.1009	0.0009	0.0019	0.0016
8	0.0186	0.0181	0.3294	0.0032	0.0059	0.0054
9	0.0050	0.0065	0.0751	0.0008	0.0013	0.0013
10	0.0083	0.0105	0.1223	0.0014	0.0024	0.0022
11	0.0034	0.0048	0.0396	0.0005	0.0010	0.0008
12	0.0044	0.0035	0.0527	0.0005	0.0010	0.0009
13	0.0111	0.0278	0.0992	0.0087	0.0151	0.0153
14	0.0659	1.0135	0.0202	0.0395	0.0294	0.0408
15	0.0439	0.0377	1.0083	0.0088	0.0138	0.0153
16	0.0556	0.0474	0.0757	1.0266	0.0446	0.0481
17	0.0325	0.0349	0.0320	0.0276	1.0121	0.0182
18	0.2961	0.2831	0.2972	0.5573	0.4471	1.0492

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