Application of Input-Output Analysis to a Simple Model Emphasizing Agriculture

(A Study of the Interdependence of Agriculture and Other Sectors of the National Economy)

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With growing commercialization of the national economy, agriculture and industry have become increasingly interdependent. The development has extended so far that the major problems found in agriculture now are those growing out of interdependence with other sectors of the national exchange economy. A slight swell in farm production, relative to employment and output in the rest of the economy, causes a rapid recession of farm income. A small decline in farm output, relative to employment in the national economy, causes farm prices to spiral upward. Then, too, it is known that depression or prosperity in agriculture is largely a function of the state of economic affairs in nonagricultural sectors of the national economy. While a few of these general qualitative interrelationships between agricultural and other sectors of the economy are known, knowledge of the exact quantitative inter-relationships is meager. More quantitative information of the economic inter-relationships will be important in the years ahead. The major and basic problems which face the agricultural sector of the national economy are in the realm of interdependence coefficients.

OBJECTIVES

The main objective of this input-output study is to provide added information on interdependence coefficients between agriculture and industry. The magnitude of input-output and interdependence coefficients between different sectors of agriculture and between agriculture and other industrial sectors can be used for several purposes: (1) to determine the flow of products from agriculture to other industrial sectors as increases come about in national income, total population and consumer expenditures (the "final bill of goods" in the national economy); (2) to determine the effect of production control, expanded output or subsidy in one sector of agriculture on other sectors of agriculture or nonagricultural sectors of the national economy; (3) to predict the effect of increases or decreases in international trade on flows of products and resources to and from agriculture; (4) to compare the relative change in productivity of various economic sectors; and (5) to determine the interdependence of agriculture and other industrial sectors under varying conditions of prosperity and depression.

While this study was designed to apply particularly to agriculture, the estimation of coefficients for agriculture and the model upon which they are based necessarily gives information for other sectors of the economy. Auxiliary objectives of the study, therefore, are: (1) to formulate a mathematical model of input-output analysis applicable especially to agricultural sectors and also to other sectors of the economy; (2) to provide further empirical application of input-output analysis in estimating input-output parameters from presently available statistics; (3) to interpret, in terms of present and prospective economic problems, empirical solutions of a Leontief system specifying the interdependence of agriculture and other sectors; (4) to provide a basis for improving future empirical models related to agriculture; (5) to observe, from input-output analyses of three points in time, changes over time of input relations and interdependence coefficients among the economic sectors; (6) to investigate the validity of the theoretical assumptions of the Leontief system when applied to a study of agricultural problems and to point out some difficulties encountered in the application of this type of analysis to agriculture.

This is a modest study dealing with two sectors of agriculture in relation to other sectors of the national economy. Subsequent studies will be made of additional agricultural sectors. This analysis deals with interdependence of production and attempts to estimate production or input-output coefficients of the Leontief type. Input-output of the Leontief type involves two basic activities (22): (1) estimating the production coefficients (input coefficients) for each sector of the economy studied; and (2) estimating the coefficients of interdependence between household consumption and the levels of output of all sectors. The first set of coefficients is estimated directly from the data of aggregate flows among the sectors of the economy. The second set is determined from the mathematical relationships between the flows of resources and the level of household consumption. Presentation of the procedures and results of this study are arranged as follows: (1) explanation of methods of compiling basic information for the input-output analysis (presented in the front section along with a discussion of the economic model); (2) deriva-

[1] Project 1135, Iowa Agricultural Experiment Station.

tion and explanation of the input coefficients for each sector and the interdependence coefficients; (3) presentation of the changes in the structural relationships of the economy over time, through an analysis of data from the three years 1949, 1939 and 1929; (4) finally, problems in application of input-output analysis.

An input-output study of all particular sectors of the United States economy would involve an extremely large number of variables. The number of possible mathematical equations required for estimating input-output coefficients in each industry is great. For this reason and since (a) resources available for this study were limited, (b) the study is partly of a methodological nature and (c) main interest is in agriculture, the economy has been divided into only five sectors: primary agricultural production, secondary agricultural production, all industry and services, foreign trade and government. The model is thus concerned with a limited number of sectors; the production activities within a sector are "similar" but do not necessarily represent a homogeneous product. While the coefficients between agriculture and one sector of industry would, if industry were divided into several sectors, differ from those presented here, the analysis presented allows measurement of the effect of all industrial sectors, as one aggregate, on the inputs and outputs of agriculture. Even then, the process of aggregating production into a few sectors is difficult; special consideration is given to aggregation problems in another section of this report.

A flow of goods and services exists among sectors of the economy where one sector uses the product of another sector. These goods and services are the "flows" analyzed later. The flows provide the basic information for an input-output analysis of the interdependence of the sectors under consideration. The goods and services which flow to households are referred to as the "final bill of goods." In an "open" model of input-output analysis, the final bill of goods (household consumption) is taken as given and is determined outside the system of relationships among the other flows; that is, the "final bill of goods" represents the final demand determined by individuals' choices and tastes.

SOURCE OF DATA

The first step in an input-output study is to determine the flows among the sectors, the total net output of each sector and the final bill of goods for a single 12-month period. In completing this step, data from secondary sources for the years 1949, 1939 and 1929 were collected and aggregated into the five sectors for the United States economy. The data for 1949 are used for analysis of (a) the interdependence among the sectors and (b) the effects of predicted changes in production and consumption at a single point in time. The data of the other years are used with those of 1949 to detect changes in structural relationships among sectors over time. The secondary data used are census-type figures or estimates published by the Bureau of Agricultural Economics, the United States Department of Agriculture, the Department of Commerce, the Division of Labor Statistics and the Bureau of the Census.

In some instances, it was necessary to observe variables from more than one source. National income statistics provided the major source of information for sectors other than agriculture. The figures involve possible error of estimation where they are extrapolations from census data. These possible estimational errors are not considered in the input-output technique; data are taken as representing population parameters.

FLOWS, NET OUTPUTS AND THE FINAL BILL OF GOODS

The variables of the input-output analysis consist of: (1) the flows of goods and services among the five sectors discussed earlier; (2) portions of outputs which flow to household consumption (final bill of goods); and (3) the total net output of each sector. The variables of each sector and the labor services of households (labor inputs to other sectors) are explained separately below. The variables within each sector of the economic model are discussed in the following order: (1) the variables which describe the flows of goods and services from the "producing sectors" to the "using sectors," (these variables represent the inputs for production activity in the various "using sectors".); (2) the variable which makes up the portion of the output of a sector which flows directly to household consumption; and (3) the variable which describes the total net output of the sector. Some simple mathematical notation has been introduced to avoid the necessity of making a descriptive title for each variable and to relate the economic model to the mathematical model employed.

PRIMARY AGRICULTURAL PRODUCTION

Primary agricultural production was classified to include crop production and all other production where the products are harvested from the culture of plant life. Crops listed in "Agricultural Statistics" (38) and forestry production constituted the agricultural enterprises included in the sector.

The variables (flows to other sectors of the system) of the economic model included in primary agricultural production were x_{12}, x_{13}, x_{14}, x_{15}, Y_1 and X_1.[2] The subscripts indicate the direction of the flow, i.e., x_{12} is the quantity of net output of the first sector flowing to the second sector over some specified period. The subscript on the Y and X indicate the particular sector. The description of the variables is as follows:

x_{12} is the value of all feed fed to livestock including farm-grown grains, forage, hay, pasture and the net increase in

[2] x_{12} is the quantity of net output of primary agricultural production flowing to secondary agricultural production. x_{13} is the quantity of net output of primary agricultural production flowing to the industry and service sector. x_{14} is the quantity of net output of primary agricultural production flowing to foreign trade (exports). x_{15} is the quantity of net output of primary agricultural production flowing to government. Y_1 is the quantity of net output of primary agricultural production flowing directly to households (farm products consumed by farm households and products exchanged for consumption goods). X_1 is the net output of primary agricultural production. The part of total output used by the sector which produced it is not included in the input-output analysis. For example, the quantity of crop production used on farms for seed is not included in the flows of primary agricultural production. Therefore, output of the sector is referred to as net output rather than total output.

stocks of grain stored on farms and in bins owned by the Commodity Credit Corporation. The physical quantity of feed fed to livestock was obtained from the distribution of feed crops and other crops fed to livestock, (34, pp. 7-10 and pp. 31-32) and (38). Where the distributions of crops were estimated for the crop year rather than the calendar year, a moving average of 2 years with a weight, 0.50, was used to estimate the quantity of feed fed to livestock during the calendar year. The quantities of each feed fed to livestock were multiplied by the average prices received by farmers during the calendar year. Average prices were obtained from (31), (32) and (39). Where monthly prices were not available, the seasonal average price reported in (38) was used. Little information was available on the estimates of the value of pasture. Jennings (18, p. 14) made estimates of the total feed units of pasture produced in the periods 1941-42, 1938-40 and 1929-33. These estimates were extrapolated to the years included in this study by the ratio of total acres in pasture to total acres in farms determined from the agricultural census (34). One pasture feed unit was assumed equivalent to 1 pound of corn. The number of pasture feed units was multiplied by the average price of a pound of corn to estimate the value of pasture consumed by livestock. The net increase in the value of stocks of grain and other crops stored on farms and in bins owned or controlled by the Commodity Credit Corporation was estimated by the difference between stocks of grain at the beginning and end of the year (34) (38). The value was determined on the basis of average price or seasonal average price, depending upon the crop involved.

x_{13} is the value of all crops which flowed to industry, plus the value of forest products produced during the year. The quantity of crops flowing to industry was obtained as a residual quantity. The residual was computed by subtracting the following from the total production: feed, seed, direct consumption on farms, exports, military procurement and the change in inventories held on farms and in government bins. This residual was valued at the average price or seasonal average price depending upon the crop. The procedure was followed for all crops reported in (38), and the residua's were added to obtain an estimate of the value of crop production flowing to the industry and services sector. The value of forest products, including the value of "free use" timber and products of farm forestry (38), was added to the value of the residual quantity of crop production discussed above. The method of estimating the quantity of feed, direct consumption and military procurement is discussed at a later point. Exports are reported for the period July 1 to June 30 in (38); therefore, a moving average of 2 years with a weight, 0.50, was used to estimate the quantity of the crop exported during the calendar year. The estimate of the quantity of the crop used for seed was the previous year's estimate of the disposition of the crop for seed. The previous year's estimate of seed is based on the number of acres seeded the following year (38).

x_{14} is the value of all crops exported and assumed to flow to the foreign-trade sector. Most of the processing services for exported agricultural commodities is transportation and preparation for shipment. The values of these services are included in the industry and services sector rather than in the agricultural sector. In reality, all products involved in foreign trade pass through wholesale or retail firms before they reach the export market. Hence, all exports might be considered a flow to the industry and services sector. If this allocation were chosen, there would be no interdependence coefficients to express the relationship between foreign-trade activity and other economic sectors, particularly agriculture. Since it was desirable to study the relationship between agricultural production and foreign-trade activity, the net output of a sector which ultimately reaches the export market, without appreciable change in form, was considered to be a flow from the sector to the foreign-trade sector. Services performed by firms and households (labor services) in carrying out the activities of foreign trade were included in the industry and services sector. The quantity of each crop exported was given in (38); however, these quantities were used only in determining the residual quantity flowing to the industry and services sector. The annual value of crops exported was obtained from foreign-trade statistics (36). Using foreign-trade statistics avoided the use of a moving average in determining the annual export of crops. There are some discrepancies in the valuation of the flow from agriculture to exports, since foreign-trade statistics do not value the products at producers' prices. Producers' prices were used for all other flows from primary agricultural production. These discrepancies are not serious in a small model. Other studies using large input-output models have given special consideration to this problem (6, p. 102). The values of the following exported commodities were included in the flow from primary agricultural production to foreign trade: (1) grains; (2) hay; (3) processed fruits; (4) fresh fruits; (5) fresh vegetables; (6) nuts; (7) seeds; (8) tobacco, unmanufactured; (9) cotton, unmanufactured; (10) wood, unmanufactured.

x_{15} is the flow from primary agricultural production to government. Included in this flow is the value of crops purchased by government, conservation payments to farmers, payments for naval stores and payments under the Sugar Act. Crop production flowing directly to government includes those quantities procured for military exports and for military food use. Wheat was the only commodity which entered into this category in 1949. No quantities were given for the other 2 years included in the study. The quantity of wheat purchased by government under military procurement (38) was valued at the average price of wheat during the year. The aggregate estimates of government payments to agriculture were given in (38) for all years from 1929 to 1950. Government subsidy payments to agriculture are included in this variable since they are an additional return for agricultural output above that which was received through the market. This procedure can be criticized on the ground that some subsidies to agriculture, those in 1939, are payments to withhold production rather than a reward for production which actually took place. Subsidies to agriculture could be treated as a transfer payment in the input-output model. This method would eliminate the subsidy flow from the model. However, a large portion of subsidies to farmers, such as ACP payments, are payments for practices which result in greater output; even the "parity payments" in 1939 (to compensate for decreased acreages) likely had the effect of encouraging a more efficient agriculture and a greater production.

Y_1 is the value of crops used by farm households and exchanged for consumption goods. The value of household consumption on farms and the value of crops exchanged for consumption goods were obtained from the distribution of each crop (38). For those crop distributions, reported on a crop-year basis, a moving average of 2 years with equal weight, 0.50, was used to estimate direct farm-household consumption during the calendar year.

X_1 is the value of net output of primary agricultural production. It was obtained by adding the dollar value of all flows from primary agricultural production to other sectors.

SECONDARY AGRICULTURAL PRODUCTION

Secondary agricultural production was classified to include all agricultural production resulting from the processing of crops through livestock and storage activities. Storage of grain on farms and in bins owned or controlled by the Commodity Credit Corporation was included as secondary production. Grain storage was treated as secondary production, because grain moving to storage has reached its terminus in the crop-production process but is used in later production of livestock; storage itself is a type of production giving more "time value" to crops. The variables of the economic model included in secondary agricultural production are x_{21}, x_{23}, x_{24}, x_{25}, Y_2 and X_2.

x_{21} is the flow of secondary agricultural output to primary agricultural production. Manure produced by livestock and used on farms is the only resource included in this flow. The value of manure produced by livestock (assumed to be a flow into crop production) was estimated on the basis of total value of feed consumed by livestock. The value of a ton of manure was estimated from the average NPK content of manure and the price of three mixed commercial fertilizers. An average ton of barnyard manure contains 10 pounds of nitrogen, 5 pounds of phosphorous and 10 pounds of potassium (27, p. 209). The 1949 price of a pound of each nutrient was estimated to be 11 cents for nitrogen, 9 cents for phosphorous, and 9 cents for potassium, using the prices of three mixed fertilizers: 2-12-6; 3-12-6 and 4-12-4 (38). Prices paid by farmers for mixed fertilizers were not available for 1939 and 1929; therefore, the value of a ton of manure for 1949 was adjusted by the index of prices paid by farmers for fertilizer (38). The estimated values of a ton of manure for the 3 years were \$2.53 for 1949, \$1.70 for 1939 and \$2.19 for 1929.

x_{23} is the flow of secondary agricultural output to industry and services. Included in this flow are the value of all livestock for slaughter and all livestock products. Livestock products sold include dairy products, wool, mohair and eggs. Estimates of livestock sold for slaughter and livestock products sold for other purposes were obtained from (38).

x_{24} is the flow of secondary agricultural products to foreign trade (exports). The value of livestock and raw livestock products makes up the flow of commodities in this category. As previously indicated for crop exports, livestock and livestock products exported also may not actually be considered as flowing directly from agriculture to the export market. To observe the interdependence between secondary agricultural production and exports, it was assumed that those products flowing from secondary agricultural production to the export markets did not go through any major change in form because of processing and handling for shipment to foreign markets. The values of the following commodities exported in the years 1949, 1939 and 1929 were included in the estimate of the variable (36): (1) animals, live, edible; (2) animals, live, inedible; (3) eggs, in shell and (4) wool, mohair, angora rabbit hair, unmanufactured.

Y_2 is the flow of secondary agricultural production to the final bill of goods (household consumption). The value of livestock and livestock products consumed on farms or exchanged for other consumption goods provide the estimate of the flow. Farm household consumption of livestock was obtained from (38) for each of the following classes of livestock: cattle, hogs, sheep and lambs, chickens and turkeys. To this was added the value of milk products and eggs consumed by farm households (38).

X_2 is the value of the net output of secondary agricultural production. It was obtained by adding the dollar value of all flows from secondary agricultural production to other sectors.

INDUSTRY AND SERVICES

Production of all nonfarm industries and services was aggregated into the industry and services sector. The industrial sector contributes the greatest portion to the final bill of goods (household consumption) and contributes most to employment in the United States. The influence of the degree of aggregation in the industry and services sector upon the estimates of the interdependence of economic sectors is discussed in a later section. Government enterprises, such as postal service, etc., are included in this sector. The variables of industry and services are x_{31}, x_{32}, x_{34}, x_{35}, Y_3 and X_3.

x_{31} is the flow from industry and services to primary agricultural production. The value of commercial fertilizers, machinery repairs, building repairs, fuel and oil, new machinery and equipment, seeds purchased by farmers and miscellaneous production expenses make up the flow. The value of fertilizer and lime used on farms was obtained from (38) except for the year 1949. The 1949 estimates were considered to be subject to considerable adjustment; therefore, more recent estimates from (29) were used for 1949. The estimate of production expense for operation of motor vehicles includes expenditures for gasoline, oil, tires and repairs on tractors. Forty percent of the automobile expense is included in estimates for 1939 and 1929, and 50 percent of the automobile expense is included in the 1949 estimate (38). Depreciation on buildings, machinery and equipment reported in (38) was the investment needed to maintain the condition of farm buildings, machinery and equipment at the beginning of the year in a constant state of repair. Only depreciation on machinery and equipment was included in this variable. The 1949 figure for total depreciation given in (38) was reduced by the value of new buildings, building repairs and fence construction given in (29, p. 39). The 1939 and 1929 totals given in (38) were reduced by the expenditures and depreciation on buildings given in (33, p. 42). Miscellaneous production expenses for insecticides, twine, ginning, irrigation, seed and nursery stock given in (38) are aggregated with electricity, insurance, veterinary services, dairy supplies and other livestock expenses. Only estimates for seed expenses (30, p. 8) are given separately. Since seed includes the major part of the miscellaneous production costs of crop production, only this item was included in this variable. The balance of miscellaneous production expenses was considered a flow to secondary agricultural production.

x_{32} is the flow from industry and services to secondary agricultural production. The value of commercial feeds fed to livestock, new construction of buildings and fences, electric power, and veterinary services and supplies makes up this flow. The value of commercial feeds purchased by the secondary agricultural production sector was estimated by multiplying the annual disappearance of feedstuffs by the average price per ton, bagged in wholesale lots, at leading markets (38). Disappearance of commercial feeds are given for the year beginning Oct. 1; therefore, a moving average of 2 years with a weight, 0.50, was used to estimate the disappearance during the calendar year. No comparable data are available for 1929. The total production expense for feed bought for all years is given in (38). The average ratio of total value of feed bought and value of commercial feed consumed in 1949 and 1939 was used to estimate the value of commercial feed bought by farmers in 1929. Depreciation and repair on buildings and fences was available for 1949 (29, p. 39). Estimates of these expenses for 1939 and 1929 included only depreciation and expenses on buildings (33, p. 42). Miscellaneous production expenses less the value of seed purchased were included in this variable as was discussed under the variable x_{31}.

x_{34} is the flow of goods from industry and services to foreign trade, namely, exports. Exports of industrial production were obtained from foreign-trade statistics (36). The total value of general exports was adjusted by the value of agricultural exports included in x_{14} and x_{24} and the value of government sales abroad (40, p. 155).

x_{35} is the flow from industry and services to government. This flow includes the value of the goods and services purchased by government from business and industry reported in (40), excluding the value of goods and services purchased by government enterprises. The total value of government purchases was reduced by the value of agricultural crops purchased by government previously reported in x_{15}. The "balance on government subsidies and government enterprises" reported in the Department of Commerce's accounts of national income was included in this variable. In the model, government enterprises are a part of the industry and services sector; therefore, this item was included in the flow from industry and services to government.

Y_3 is the flow from industry and services to households. It represents the value of the final goods produced by industry and services, excluding goods used for capital investment and replacement. Household consumption of industrial production and services was estimated from personal expenditures for durable and nondurable goods and services. The annual value is reported in national income statistics (40, pp. 198-199). Total personal expenditure reported was adjusted by deducting the value of food produced and consumed on farms, the value of fuel and ice produced and consumed on farms and rental value of farm houses (40, pp. 192-193).

X_3 is the net output of industry and services. The value of the net output was obtained by adding the dollar value of all flows from industry and services.

FOREIGN TRADE

Foreign-trade activity is treated as a sector using inputs and producing outputs. Exports are the inputs or flows from other sectors to the foreign-trade sector, and imports are the outputs of the sector. A problem arises in input-output models as to how to allocate imports among the other sectors of the economy. Two alternatives are available: (1) Imports can be allocated to the sectors which produce similar products. For example, imports of agricultural products would be allocated to the agricultural sector and added to the net output of agriculture. (2) Imports can be allocated directly to the sectors which use them. Leontief (22, p. 164) used the first method. It is argued that the technical structures of the sectors of the economy are determined by ratios of inputs to outputs regardless of the origin of the inputs. For example, the flow of cotton to industrial use does not distinguish between domestic cotton and imported cotton. This method does not separate domestic production from foreign production when the results are used to guide policies affecting domestic production. The second alternative was used in this study. Imports were allocated directly to the sectors which used them. Cotton produced by domestic agriculture is included in the flow from primary agricultural production to industry and services (x_{13}). Imported cotton is included in the flow from foreign trade to industry and services (x_{43}). This method of allocating imports does separate domestic production from foreign production. Input-output models using the second choice may be more useful in determining policies affecting domestic production. In allocating imports to the sectors which use them, imports were assumed to flow to three sectors: industry and services, government and households. The flows from foreign trade (imports) were designated x_{43}, x_{45} and Y_4.

x_{43} is the flow of imports to industry and services. The value of imports consumed by industry and services was the total value of general imports (36) less the value of imports allocated to households and government.

x_{45} is the flow of imports to government. It is represented by the value of government purchases from abroad. The value of government purchases from abroad was given in the Department of Commerce's accounts of government expenditures in the estimates of national income (40, p. 155).

Y_4 is the flow of imports to households. These are commodities which are purchased for final consumption. Again, these commodities may not flow directly to households but are handled by retail firms. In estimates of national income, finished manufactures and manufactured foodstuffs are not included in personal consumption expenditures but in net foreign investment. For this reason, the Department of Commerce's aggregation of general imports by economic classes (crude materials, crude foodstuffs, semimanufactures and finished manufactures [36]) was used to determine the flow of the imports to households. Manufactured foodstuffs and finished manufactures less government purchases from abroad were used to estimate the flow of imports to direct consumption by households.

X_4 is the value of general imports. It represents the "net output" of the foreign-trade sector of the economy.

GOVERNMENT

Government is treated similarly to any other sector of the economy in input-output studies. It can be visualized as a sector producing an output of services consumed by other sectors and consuming the products of other sectors as its inputs. The flow of government services (output) is measured by the value of government receipts, and the flow from other sectors of the economy to the government sector (input) is measured by government expenditures. The flows of government services to other sectors are represented by x_{51}, x_{52}, x_{53}, x_{54} and Y_5. The total value of government services is represented by X_5.

x_{51} is the flow of services to primary agricultural production. Real-estate tax and personal-property tax on machinery was assumed to be a measure of the flow of services. Real-estate tax and personal-property tax paid by agriculture were obtained from (38). All real-estate tax paid by farm owners was included as a payment to government by the primary agricultural sector. The portion of personal-property tax paid to government by primary agricultural production was estimated by the ratio of the total value of all livestock on farms at the beginning of the year and the total farm investment in livestock, machinery and equipment at the beginning of the year.

x_{52} is the flow of government services to secondary agricultural production. It was estimated by the value of personal-property taxes on livestock. The portion of personal-property tax paid by agriculture and not included in x_{51} constituted the estimate of personal-property tax paid by secondary agricultural production.

x_{53} is the flow of government services to industry and services. It was estimated by the value of corporate tax accruals, property and personal taxes on business, indirect business tax and non-tax accruals. The estimate of corporate profits tax accruals was obtained from (40, p. 154). Indirect business tax and nontax accruals, less the real-estate and personal-property tax paid by agriculture, were included in this variable as the indirect business tax and nontax accruals paid by the industry and services sector.

x_{54} is the flow from government to the foreign-trade sector which is made up of two components: (1) the flow of government services to the foreign-trade sector and (2) the flow of goods and services sold abroad by the United States government. The flow of government services can be thought of as the services which government performs in the conduct of foreign-trade activity; however, it does not include the salaries of government customs officials. This flow was estimated by the value of government revenues from customs (40, pp. 154-155). The flow of goods and services sold abroad by government was estimated by gross sales of government abroad (40 pp. 154-155).

Y_5 is the flow of government services to the household sector (final bill of goods). This flow is estimated by the value of personal tax and nontax revenues not chargeable to business and the contributions of employees to social insurance. Personal tax and nontax revenues not chargeable to business were obtained from (40, p. 154), and contributions of employees to social insurance were obtained from (40, p. 155).

X_5 is the value of government expenditures reported in (40) plus the subsidy payment to agriculture. It represents the net output of the government sector.

HOUSEHOLD (LABOR)

Although households do not constitute a sector of the economy in the same sense as other sectors in the input-output analysis, the sector does supply the primary factor of production (labor). The value of labor services is included in the analysis to predict the level of employment associated with any assumed level of net output in other sectors and with any assumed level of final bill of goods (household consumption). The flows of labor services from households to other sectors are represented by x_{61}, x_{62}, x_{63} and x_{65}. The level of employment is represented by X_6. The data used to estimate the input of labor services in each sector of the economy, except agriculture, were obtained from the Department of Commerce estimates of national income (40). The estimate of wages and salaries for agriculture in national-income statistics includes only hired labor and ignores the value of family labor used in the agricultural sectors. Other sources are available for estimating the hours of labor required in agricultural production which do include family labor.

x_{61} is the value of all labor used in the production of crops and forestry products. An aggregate estimate of labor required by enterprises on farms in terms of man-hours was available in (38). The estimates were given for all livestock production, all crop production and farm maintenance. The man-hours of labor required on farms for crop production, plus a proportionate share of the man-hours required for farm maintenance, were multiplied by the average hourly wage for farm labor without board (38). The hourly wage was not reported for 1929; therefore, the wage per day without board was used and an 8-hour day was assumed. The proportionate share of the labor requirement for farm maintenance was estimated to be the same as the proportion of all other agricultural inputs used for primary agriculture. The percent allocated to primary agricultural production was 67.3 percent for 1949, 68 percent for 1939 and 73 percent for 1929. The hourly wage rates were 0.68 dollars per hour for 1949, 0.20 dollars per hour for 1939 and 0.28 dollars per hour for 1929. Wages and salaries paid forestry workers (40, pp. 160-161) and supplements to wages and salaries of forestry workers (40, pp. 162-163) were added to the value of farm labor used in primary agricultural production.

x_{62} is the value of labor used in the production of livestock. The estimate of man-hours of labor required for livestock production, plus a proportionate share of the man-hours of labor required for farm maintenance (38), was multiplied by the same hourly wage rates used in estimating x_{61}. The proportionate share of man-hours of labor required for farm maintenance was estimated by the ratio of the total value of all other inputs to secondary agricultural production and the total value of all inputs to agriculture other than labor. The percent allocated to secondary agricultural production was 32.7 percent for 1949, 32 percent for 1939 and 27 percent for 1929.

x_{63} is the value of labor used in the industry and services sector. It was estimated by total wages, salaries and supplements to wages of workers in industry and services and government enterprises. The wage bill for industry, services and government enterprises was determined by adding the value of wages and salaries by industry given in (40, pp. 160-161) for all industries and services except farms, forestry and general government. To this was added the value of supplements to wages and salaries for all industries and services except farms, forestry and general government (40, pp. 162-163).

x_{65} is the value of labor used by government. It was estimated by the total wages and salaries, and supplements to wages and salaries of government employees. Government salaries and wages (40, p. 155), plus supplements to wages and salaries of general government (40, pp. 162-163), were reduced by the amount of wages and salaries paid by government enterprises (40, pp. 162-163). It was assumed that employers' contributions to social insuraance were payments to households for labor services which in reality reach workers at retirement age. In turn, these items were excluded from the flows to government.

INTER-SECTOR FLOWS

The previous section describes the variables included in the input-output model and the sources of the data used to estimate the flows of resources from one sector to another. Once the estimates of the flows of resources among the sectors of the economy have been obtained, relationships among the sectors can be constructed; these express the magnitude of the interdependence of production in the various sectors.

The empirical data are arranged into tables to facilitate the derivation of the input coefficients of each sector. The number of input coefficients for any one particular sector is equal to the number of other sectors contributing to the product of the particular sector. An input coefficient expresses the amount of product from one "contributing" sector necessary for a unit output of the sector in question. Once these input coefficients, which are of interest in themselves, have been computed, they are used for determining the interdependence coefficients. The input coefficients are first used, however, to set up mathematical relationships which describe the activities of the economy in a single year. By examining the input coefficients, we can determine their magnitude in relation to the net output in the particular sector. For example, a question in the agricultural economy is that of the inter-relation of crop and livestock production. What are the requirements placed on primary agriculture when secondary production is increasing? What amount of crop product from primary agriculture is necessary for each "unit increase" in output of livestock?

From the basic input and flow relationships describing the activities of the economy, estimates of parameters describing the relationships between consumption and production are derived. These relationships are referred to as the interdependence coefficients to distinguish them from the previously discussed input coefficients. They show the changes in output of each sector necessary for or corresponding to each unit change in consumption by households.

Table 1 shows the dollar value of all the flows among the sectors, components of the final bill of goods and the net outputs of the five sectors for 1949. The first column in the table shows the flows of goods and services to primary agricultural production from all the other sectors. No flow appears in the table from foreign trade to primary agricultural production. Where no flow appears between two sectors, it was assumed that no products of the sector producing the outputs are used in the production of sectors consuming the outputs. Some of the gross total output of a sector is consumed by the same sector which pro-

TABLE 1. DISTRIBUTION OF INPUTS AND OUTPUTS OF THE UNITED STATES ECONOMY, 1949.

(MILLIONS OF DOLLARS)

Sectors producing the net output	Sectors consuming the net output						
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government	Household consumption	Net output
Primary Agricultural production	-----	(x_{12})	(x_{13})	(x_{14})	(x_{15})	(y_1)	(X_1)
	-----	11,575	7,298	1,795	527	601	21,796
Secondary agricultural production	(x_{21})	-----	(x_{23})	(x_{24})	-----	(y_2)	(X_2)
	697	-----	15,304	40	-----	1,721	17,762
Industry and services	(x_{31})	(x_{32})	-----	(x_{34})	(x_{35})	(y_3)	(X_3)
	7,330	2,579	-----	10,587	19,988	175,682	216,166
Foreign trade (imports)	-----	-----	(x_{43})	-----	(x_{45})	(y_4)	(X_4)
	-----	-----	4,636	-----	4,146	1,987	10,769
Government	(x_{51})	(x_{52})	(x_{53})	(x_{54})	-----	(y_5)	(X_5)
	768	56	31,628	693	-----	21,565	54,700
Household labor	(x_{61})	(x_{62})	(x_{63})	-----	(x_{64})	-----	-----
	7,759	4,980	117,309	-----	20,424	-----	-----
Total outlays	16,494	19,190	176,175	13,115	45,085	201,557	-----

duced it. For example, secondary agricultural production produces livestock which is used to replace breeding animals. This part of the total output does not appear in the input-output flows. In input-output analysis, it is assumed that any output of a sector that is consumed by the same sector is necessary for the production of the net output which eventually flows from it.[3] Likewise, no variables are included denoting a flow of primary agriculture to itself. The sixth column of table 1 is the final bill of goods (household consumption). Each figure in this last column is the dollar value of products and services produced by the corresponding sector and consumed by households during 1949. Net output (column 7, table 1) is the total dollar value of all goods and services, produced by the sector, which flowed to other sectors or was consumed by households.

The input-output flow table shows the dollar values of physical product and services from other sectors which were consumed by a particular sector in producing the latter's net output. Primary agriculture consumed 697 millions of dollars' worth of secondary agricultural output, 7,330 millions of dollars' worth of industry and services output, 768 millions of dollars' worth of government services and 7,759 millions of dollars' worth of labor services to produce 21,797 millions of dollars' worth of net output.

INPUT COEFFICIENTS

The flows in table 1 provide the information for estimating the relationship between the inputs and outputs of each sector. Again, the input coefficients show the amount of flow from other sectors necessary for a "dollar's worth" of net output of the sector in question. These input coefficients are computed by dividing each flow in the columns in table 1 by the corresponding net output of the sector in question in the last column of the table. To calculate the input coefficients for primary agricultural production, the flows from the other sectors (697, 7,330, 768 and 7,759) are divided by 21,797. The input coefficients are 0.032 for secondary agricultural products, 0.336 for industry and services products, 0.035 for government services and 0.356 for labor services. This procedure has been carried out for all five sectors, and the input coefficients for 1949 are presented in table 2. The input coefficients are identified as a_{12}, a_{13}, a_{14}, etc. By a_{12}, we refer to the "dollar's worth" of input from primary agriculture necessary for a "dollar's worth" of net output in secondary agriculture; the subscripts parallel those for the flows of the previous section.

The input coefficients calculated from the data in table 1 are the technical production coefficients for the aggregate production within each sector. They are assumed, by the input-output type of analysis, to be constant for deviations from the values observed in 1949. We can now assume changes in the quantity of output produced by a sector and examine, within the constraints of linearity imposed by the technique, the impact of the change upon production of other sectors. First, assumed changes in the level of output in the two agricultural sectors will be examined to illustrate the type of analysis which can be made from the technical production coefficients computed from the 1949 data. Second, postulated changes in both the level of output and the technical coefficient will be used to predict future requirements of resource flows among the sectors, should the designated changes take place. Third, the input-output technique will be ap-

[3] This part of the output of a sector does not depend "directly" upon flows from any other sector and no separate input coefficient is computed for it. Feed is required to produce replacement livestock in secondary agriculture. However, the flow of feed from primary agricultural production for this purpose is computed as a component of the input coefficient for livestock which actually moves out of secondary agriculture. The flows into a sector can be thought of as the quantity of resources required to produce the flow of product out of the sector and assure a perpetuation of the flow. For this reason, no items appear in the diagonal of table 1.

TABLE 2. TECHNICAL INPUT COEFFICIENTS AND CONSUMPTION OF THE UNITED STATES ECONOMY, 1949.

Sectors producing the net output	Sectors consuming the net output					
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade	Government	Household (consumption) millions of dollars
Primary agricultural production	-----	(a_{12})	(a_{13})	(a_{14})	(a_{15})	(y_1)
	-----	0.652	0.034	0.167	0.010	601
Secondary agricultural production	(a_{21})	-----	(a_{23})	(a_{24})	-----	(y_2)
	0.032	-----	0.071	0.004	-----	1,721
Industry and services	(a_{31})	(a_{32})	-----	(a_{34})	(a_{35})	(y_3)
	0.336	0.145	-----	0.983	0.365	175,682
Foreign trade	-----	-----	(a_{43})	-----	(a_{45})	(y_4)
	-----	-----	0.021	-----	0.076	1,987
Government	(a_{51})	(a_{52})	(a_{53})	(a_{54})	-----	(y_5)
	0.035	0.003	0.146	0.064	-----	21,565
Household labor	(a_{61})	(a_{62})	(a_{63})	-----	(a_{65})	-----
	0.356	0.280	0.543	-----	0.373	-----

plied as a method of estimating future allocation of resources to attain an assumed level of agricultural production. Finally, the labor coefficients for each sector will be used to estimate the level of employment associated with assumed levels of net output and an assumed level of household consumption (final bill of goods).

Using the coefficients in table 2, we can observe the impact of changes in the net outputs of primary or secondary agriculture or in production control upon the flows from other sectors. In 1949, 1 dollar's worth of increase in the net output of primary agricultural production would have necessitated the following increases from other sectors: 0.032 dollar's worth of net output from secondary agricultural production, 0.336 dollar's worth of net output from industry and services, 0.035 dollar's worth of government services and 0.356 dollar's worth of labor. (It must be emphasized that these coefficients represent the aggregate relationship between two sectors in 1949. They do not relate to any specific commodities which might be included in the flow of resources between two sectors.) The first coefficient is the flow of fertilizer produced by livestock per unit of net output of crops and forestry products; the second coefficient is the flow of commercial fertilizer, purchased seed, insecticides, fuel, oil, machinery and power, etc.; the third coefficient is the flow of public services rendered to agriculture by government per unit of net output of crops and forestry products. Government services can be thought of as those rendered in connection with conservation, education, research, extension, market news, weather reporting, etc. The last coefficient is the flow of the value of the operator, family and hired labor in agriculture per unit of net output in primary agriculture.

The impact of a change in secondary agricultural output also can be examined from the coefficients in the second column of table 2. A 1 dollar's worth of increase in the net output of secondary agricultural output would have necessitated an increase of 0.652 dollars worth of primary agricultural output, i.e., the quantity of feed fed livestock, including hay and pasture, would need to increase by 0 652 dollars for each dollar of increase in livestock production. Industry and services output would need to increase 0.145 dollar's worth for each 1 dollar increase in secondary output. This category includes commercial feed, veterinary supplies and services, electric power, livestock equipment, etc. Service of government would need to increase by 0.003 dollar's worth, and labor services would need to increase by 0.280 dollar's worth per dollar of net output. Thus, secondary agricultural output is more dependent on primary agriculture than on any other one of the sectors; household labor is next in magnitude of input coefficient. For primary agriculture, labor from households is the most important input while the input coefficient for industry relative to agricultural output is second in magnitude. Secondary agriculture provides a much greater input coefficient for industry than does primary agriculture, although the labor input coefficient is much greater than either. Agricultural coefficients are both small for foreign trade, relative to industry; a similar situation holds true for government.

The data can be used to calculate the percent change required in the net output of all other sectors when the net outputs of primary or secondary agriculture increase by 10 percent. Table 3 shows the absolute change in the value of the net outputs of the sectors when the value of the net output of a particular sector increases by 10 percent. The first column indicates the dollar value of increase which must occur in each sector if the dollar value of primary agricultural output is to increase by 10 percent; the second column indicates the same relationship for a 10-percent increase in secondary agricultural production.[4] A 10-

[4] Each figure in table 3 was obtained by multiplying 10 percent of the net output of each sector in table 1 by the corresponding input coefficient in table 2. For example, the absolute flow from secondary agricultural production to primary agricultural production (69,744 thousand dollars) was obtained by multiplying 10 percent of 21,797 million dollars by 0.032. The absolute increase is converted to a percentage of the 1949 net output, in table 4. Each percent in table 4 was obtained by dividing the absolute flow in table 3 by the net output of the corresponding sector in table 1. For example, the percent of increase in secondary agricultural output associated with a 10-percent increase in primary agricultural output, i.e., the input from secondary agriculture necessary to allow the 10-percent increase in output of primary agriculture, 0.392 percent, was obtained by dividing 69,744 (table 3) by 17,762,000 (table 1).

TABLE 3. ABSOLUTE CHANGE IN NET OUTPUT OF SECTORS SUPPLYING INPUTS AND LABOR SERVICES ASSOCIATED WITH A 10-PERCENT CHANGE IN NET OUTPUT, 1949. (THOUSANDS OF DOLLARS).

Sectors supplying inputs	Expanding sectors: sectors consuming inputs				
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government
Primary agricultural production	-------	5.310	3.348	0.823	0.242
Secondary agricultural production	69,744	-------	1,530,405	3,972	-------
Industry and services	733,000	257,894	-------	1,058,665	1,998,764
Foreign trade	-------	-------	463,568	---------	414,600
Government	76,766	5,555	3,162,824	69,300	-------
Household (labor)	775,924	498,032	11,730,900	---------	2,042,400

percent increase in the two agricultural sectors has little effect upon the net outputs of other sectors.

PRODUCTION CONTROLS AND RESOURCE FLOWS IN AGRICULTURE

Input-output analysis can, within the constraints of the model, be used to evaluate policies such as agricultural control programs. The previous tables provide the predicted effects of production control in a particular sector of agriculture. These figures show that in terms of interdependence, production control would be more effective in secondary than in primary agriculture. A decrease of 10 percent in primary agriculture would be, within the constraints of linearity imposed by the model, accompanied by a decrease of only 70 million dollars or 0.4 percent in secondary agriculture; a decrease of 10 percent in secondary agriculture would necessitate a reduction of 10 percent in this sector, and also it would reduce the "needed flow" from primary agriculture by 5.3 percent (table 4).[5] In other words, crop production control has a relatively small effect on livestock production, even within the constraints of the model; relaxing the model to allow nonlinear production opportunities and the possibilities of resource substitution (particularly for feeds) would likely mean an even smaller reduction in secondary output for a 10-percent reduction in primary output.

PREDICTION OF FUTURE OUTPUT

Other reports have indicated needed increases in agricultural production if the food needs of the 1975 predicted population are to be met. The United States President's Materials Policy Commission report (41, p. 64) indicates a need for a 37.9-percent increase in secondary agricultural production and a 30.3-percent increase in primary agricultural production to supply the 1975 domestic "demand" for food products. The predicted impact of these required changes in agriculture upon other sectors of the economy, as well as among agricultural sectors, can be observed from data in table 4. A 30.3-percent increase in primary agricultural production in 1949 would have necessitated: (1) a 1.18-percent increase in secondary agricultural output; (2) a 1.02-percent increase in industry and services; and (3) a 0.42-percent increase in government services.[6] A 37.9 percent increase in secondary agricultural net output in 1949 would have necessitated: (1) a 20.1-percent increase in primary agricultural production; (2) a 0.45-percent increase in industry and services output; and (3) a 0.03-percent increase in government services. These statistics refer, of course, to the model used and the technological structure existing in 1949. Improved techniques would change these coefficients. Then, too, substitute resources might cause shifts between sector flows. Fertility needs in primary agriculture, for example,

[5] The reduction outlined above would be offset slightly by the difference in the absolute change of a 10-percent reduction in the sector because primary agricultural output exceeds secondary agricultural output. The magnitude of the reduction in total agricultural output would not be possible if grain previously flowing to feed use was allowed to enter other flows in the system —selling the grain in the cash market. This is actually what a marketing quota attempts to accomplish; thus, it would appear that marketing quotas must supplement any control program directed at secondary agricultural production.

[6] Input-output analysis is based on linear homogenous production functions. Therefore, effects of any percent change in net output is obtained by multiplying the percentages in table 4 by the multiple of the percent change.

TABLE 4. PERCENT OF INCREASE IN NET OUTPUTS OF SECTORS SUPPLYING INPUTS ASSOCIATED WITH A 10-PERCENT INCREASE IN NET OUTPUT, 1949.

Sectors supplying inputs	Expanding sectors: sectors consuming inputs				
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government
Primary agricultural production	-------	5.310	3.348	0.823	0.242
Secondary agricultural production	0.392	-------	8.616	0.022	-------
Industry and services	0.339	0.119	-------	0.490	0.925
Foreign trade (imports)	-------	-------	4.305	---------	3.850
Government	0.140	0.010	5.781	0.126	-------

might be met by fertilizer from industry rather than from an increase by 1.18 percent in the flow from secondary agriculture.

Table 5 shows the absolute change in the net outputs of the sectors associated with the 30.3-percent and 37.9-percent increases in agricultural net output. Secondary agriculture would depend mainly on labor (households) and primary agriculture for its postulated 37.9-percent increase (41) to meet population needs. Primary agriculture would depend more on labor and industry; improved techniques over 3 decades might throw the flows even more in the direction of industry.[7]

INTERDEPENDENCE OF CONSUMPTION AND NET OUTPUT

The previous section was concerned with the impacts of direct changes on net outputs. The input-output analysis also provides a basis for an analysis of the interdependence of household consumption and net outputs. In this section, a change in household consumption is assumed, and the impact upon net outputs of the sectors is observed with the aid of interdependence coefficients. To obtain the interdependence coefficients, it is necessary to set up a system of linear equations describing the flows among the sectors of the economy.

The following system of equations describes the 1949 activities among sectors of the United States economy:

$$X_1 - 0.652\,X_2 - 0.034\,X_3 - 0.167\,X_4 - 0.010\,X_5 = 601$$

$$-0.032\,X_1 + X_2 - 0.071\,X_3 - 0.004\,X_4 = 1{,}721$$

$$-0.336\,X_1 - 0.145\,X_2 + X_3 - 0.983\,X_4 - 0.365\,X_5 = 175{,}682$$

$$-0.021\,X_3 + X_4 - 0.076\,X_5 = 1{,}987$$

$$-0.035\,X_1 - 0.003\,X_2 - 0.146\,X_3 - 0.064\,X_4 + X_5 = 21{,}565$$

The coefficients of this system of equations are the production coefficients of each sector which were derived in table 2. X_1, X_2, X_3, X_4 and X_5 are the net outputs of the five sectors of the economy. The constants or the right-hand side of the equations constitute the final bill of goods; they correspond to the last column in table 2. Each negative term on the left-hand side of the equation is the quantity (dollar value) of product flowing from one sector to another. For example, $0.652\,X_2$ is the quantity of product flowing from the first sector (the term appears in the first equation) to the second sector (the second term in the equation). The first equation states that if we multiply the input coefficient (0.652) by the output for secondary agriculture (X_2), we get $0.652 \times 17{,}762$ or 11,575. This is the flow of goods and services from primary to secondary agriculture as indicated in table 1. Following this procedure for other sectors and subtracting the quantities from X_1 (21,797), we get a remainder of X_1 (601) flowing directly to households.

The solution of the above system of equations results in a new set of coefficients describing the relationship between the final bill of goods (consumption of households) and the level of net output. Given a final bill of goods, it is possible to predict the net output of each sector necessary to produce this same final bill of goods (household consumption). These predictions can be made from the interdependence coefficients determined from the solution of the system of equations above. The 1949 interdependence coefficients obtained from the solution of the system of equations are given in table 6.[8]

CHANGES IN CONSUMPTION

The coefficients of table 6 show the interdependence between the final bill of goods (consumption by households) and the level of output in each sector. The first column shows the amount by which an increase of 1 dollar's worth in direct demand (i.e., household consumption of primary products) in the net outputs of primary agriculture would increase the output of other sectors.[9] In 1949, 1 dollar's worth of increase in the direct demand for primary agricultural products would "result" in an increase of 0.064 dollar's worth in secondary agricultural production; 0.418 dollar's worth in industry and service production; 0.017 dollar's worth in foreign trade (imports); and 0.100 dollar's worth in government services. These quantities would be required for the increase of 1 dollar's worth of goods in primary agriculture. A 1 dollar's worth of increase in the direct demand for secondary agricultural products would result in an increase of 0.705 dollar's worth in primary agricultural production; 0.441 dollar's worth in industry and services production; 0.017 dollar's worth in foreign-trade imports; and 0.094 dollar's worth in government services. These quantities might be considered to be the "secondary effect" of an increase in direct demand for one sector; an increase of 1 dollar's worth of direct demand for secondary agriculture is forthcoming only with a flow of 0.705 dollar's worth of production from primary agriculture, 0.441 from industry, etc.

[7] The flows of government services to agriculture suppose a subsidy-production complex of the nature existing in 1949; this condition is based on the 1949 model. By 1975, the national programs may have changed greatly, and also, the relationship is not necessary for agriculture production but only expresses an extension of the 1949 input-output coefficients.

TABLE 5. ABSOLUTE CHANGE IN NET OUTPUTS ASSOCIATED WITH A CHANGE IN AGRICULTURAL NET OUTPUTS, 1949. (MILLIONS OF DOLLARS).

Sectors	30.3 percent increase in primary agriculture	37.9 percent increase in secondary agriculture
Primary agriculture	-----	4,387
Secondary agriculture	211	-----
Industry and services	2,221	977
Government	233	21
Household (labor)	2,351	1,888

[8] See the following for an explanation of the method used in solving the original system of equations: G. A. Peterson, Use of input-output analysis in estimating interdependence of agriculture and other sectors. Unpublished Ph.D. thesis. Iowa State College Library, Ames, Iowa. 1953.

[9] By "direct demand" we refer to goods demanded for consumption in households, rather than those demanded for use by other producing sectors.

TABLE 6. INTERDEPENDENCE COEFFICIENTS BETWEEN THE FINAL BILL OF GOODS AND NET OUTPUTS FOR 1949.

Sectors producing the net output	Sectors with increase in direct demand				
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government
Primary agricultural production	1.059	0.705	0.102	0.284	0.069
Secondary agricultural production	0.064	1.054	0.085	0.100	0.039
Industry and services	0.418	0.441	1.147	1.233	0.517
Foreign trade	0.017	0.017	0.038	1.046	0.093
Government	0.100	0.094	0.174	0.258	1.084

Again it can be seen that industry is relatively less dependent on agriculture than agriculture is on industry. An increase in direct demand for 1 dollar's worth of goods for primary agriculture required a 0.418 dollar flow from industry; the same increase for secondary agriculture required 0.441 from industry. However, the same absolute increase in direct demand for industrial and service products requires only 0.102 from primary agriculture and 0.084 from secondary agriculture.

We may now examine the interdependence coefficients under (1) the assumptions of specified increases in the "demand" for food and (2) the nature of the model used for input-output analysis. Resource requirements of sectors producing additional food supplies as well as other consumption goods can be analyzed with the aid of input-output analysis. Table 7 shows the absolute changes in the net outputs of each sector associated with a 10-percent increase in each portion of the final bill of goods (e.g., a 10-percent increase in population accompanied by a 10-percent increase in consumption). If, with the 1949 coefficients, demand for industry and services products is increased by 10 percent, primary agricultural net output would increase by 1.8 billion dollars, and secondary agricultural net output would increase by 1.5 billion dollars. Again, it is obvious that under the relationships examined, a 10-percent increase in "demand" for industrial production would call for a large absolute increase in agricultural production; changes in one agricultural sector have no such great effect on the other agricultural sector or on industry.[10]

[10] These estimates were obtained by multiplying (1) 10 percent of the 1949 direct contribution of industry and services to the final bill of goods (table 1) by (2) the corresponding interdependence coefficients in table 6. The absolute changes in net output have been converted to percent of 1949 net output and are entered in table 8. The percentage figures also indicate the interdependence of demand and production. A 10-percent increase in the direct demand for primary agricultural products would, in terms of 1949 coefficients, necessitate a 0.292-percent increase in primary agricultural production, a 0.022 percent increase in secondary agricultural production, a 0.012-percent increase in industry and services, a 0.009-percent increase in imports, and a 0.011-percent increase in government services. A 10-percent increase in the direct demand for secondary agricultural products would necessitate a 0.557-percent increase in primary agricultural production, a 1.021-percent increase in secondary agricultural production, a 0.035-percent increase in government services. A 10-percent increase in direct demand for products from the industry and services sector would cause an increase of 8.21 percent in primary agricultural net output and 8.37 percent in secondary agricultural net output.

TABLE 7. ABSOLUTE CHANGE IN NET OUTPUT OF ALL SECTORS ASSOCIATED WITH A 10-PERCENT CHANGE IN EACH PORTION OF THE FINAL BILL OF GOODS, 1949. (THOUSANDS OF DOLLARS).

Sectors supplying inputs	Sectors with 10 percent increase in demand				
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government
Primary agricultural production	63,677	121,353	1,789,500	56,365	148,604
Secondary agricultural production	3,820	181,327	1,486,799	19,908	84,362
Industry and services	25,137	75,828	20,156,737	244,863	1,114,047
Foreign trade	993	2,847	664,079	207,800	201,072
Government	5,996	16,119	3,059,683	51,247	2,337,947

TABLE 8. PERCENT OF CHANGE IN NET OUTPUT OF SECTORS ASSOCIATED WITH A 10-PERCENT CHANGE IN EACH PORTION OF THE FINAL BILL OF GOODS, 1949.

Sectors producing the net output	Sectors supplying the final bill of goods				
	Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government
Primary agricultural production	0.292	0.557	8.211	0.259	0.682
Secondary agricultural production	0.022	1.021	8.371	0.112	0.475
Industry and services	0.012	0.035	9.324	0.113	0.515
Foreign trade	0.009	0.026	6.167	1.930	1.867
Government	0.011	0.029	5.593	0.094	4.273

A question in agricultural organization relating to increases in output, however, is this: How can the increase in output be attained? Input-output analysis assumes that resources needed in one sector are available from other parts of the economy. This condition may not hold true for land. Agricultural output can always be increased by drawing more labor and capital resources into agriculture. However, future increases in agricultural output may well come about mainly through new techniques of production (12, p. 798). If output were to be expanded with addition of labor and capital to existing land, without new techniques, the relationship between input and output would likely be nonlinear.

EFFECT ON EMPLOYMENT

The input-output procedure also provides the information for analysis, given the constraints of the model, of the effects of specified changes in one or all sectors upon employment. From table 2, the following linear relationships between net output and employment can be constructed for 1949.[11]

$$x_{61} = 0.356\ X_1 \qquad x_{63} = 0.543\ X_3$$
$$x_{62} = 0.280\ X_2 \qquad x_{65} = 0.373\ X_5$$

These input relationships determine the dollar value of employment required for any given level of net output in the five sectors. The value of labor necessary for any output in primary agriculture, for example, is equal to the output of primary agriculture multiplied by 0.356. An increase of 1 dollar's worth of output in secondary agricultural production would require, with 1949 coefficients, an increase of 0.280 dollar's worth of agricultural labor. Similar inferences can be made from the coefficients for other sectors of the economy.

LABOR PRODUCTIVITY

In this study, labor services are measured in dollar value instead of man-hours. Hence, we have a ratio expressing value of input required for a dollar value of output. Since wage rates may differ between localities, these differences do not directly express physical differentials in labor productivity. A difference in the coefficients of agriculture and industry can be interpreted only if something is known about the comparability of labor in the two sectors and the wage rates. If we assume that wage rates sufficiently indicate these physical differentials in labor, then the difference in the value of labor required per unit of output reflects differences in the physical return to labor in two sectors.

A direct comparison between the labor coefficients for primary and secondary agriculture can be made subject to these same reservations. The coefficient tends to be larger for primary than for secondary agricultural production. An increase of 1 dollar's worth of net output in primary agricultural production necessitated 0.356 dollar's worth of agricultural labor; a dollar's worth of secondary agricultural production necessitated 0.280 dollar's worth of agricultural labor. This means that a unit of labor would produce a greater value of product in secondary than in primary agriculture. Studies in production economics have continually pointed out the possibilities for agricultural firms to increase income by increasing livestock production. Capital limitations restrict many farmers from expanding livestock organizations, however, and thus they continue to employ their resources in crop production. The system employed here cannot, of course, provide great refinements in estimating labor productivity coefficients within agriculture (although the findings are highly consistent with those obtained by other methods).

The effects of changes in the final bill of goods upon the level of employment within an agricultural sector may also be observed from the input-output procedure. By substituting the relationship between the final bill of goods and the net output of a particular sector into the appropriate labor relationship given above, the effect of a change in any part of the final bill of goods on employment in the particular sector can be determined. The 1949 relationships for agriculture were as follows:

$$x_{61} = 0.3771y_1 + 0.2511y_2 + 0.0363y_3 + 0.1010y_4 + 0.0245y_5$$
$$x_{62} = 0.0178y_1 + 0.2955y_2 + 0.0237y_3 + 0.0281y_4 + 0.0110y_5$$

ANALYSIS OVER TIME

Because of the nature of the data and the model applied to it, predictions from data for a single year must refer to the structure of production at that particular point in time, or to changes based on assumptions pertaining to this particular structure. Extrapolations to other points in time are subject to error because changes in techniques give rise to new input-output coefficients and changes in price relationships cause new resource combinations to be profitable, and different coefficients again arise (particularly where nonlinear structural relationships are involved). However, prediction of input-output coefficients at different points in time can be used to predict changes in productivity coefficients and interdependence of sectors. To allow an analysis of this nature, census years, 1949, 1939 and 1929 were selected to study the interdependence and input-output coefficients of the five "in" sectors of the United States economy. Data for 1939 and 1929, comparable to the 1949 data given in table 1, were collected and formulated into input-output flow tables. The data were then adjusted to a 1939 price level for time comparisons.

TRANSFORMING THE DATA

The original data for the 3 years were adjusted to the 1939 price level by use of the price indices for each sector. The adjusted flows for the 3 years are given in table 9. From the adjusted input-output flow tables, the technical production or input coefficients, in terms of 1939 dollars, were calculated (table 10) in the same manner as for 1949 (table 2).

STRUCTURAL CHANGES

The flows in table 9 and the input coefficients in table 10 allow us to measure changes in the structural

[11] The subscript "6" refers to employment of labor from household. The second subscript refers to the sectors specified earlier.

TABLE 9. DISTRIBUTION OF INPUTS AND OUTPUTS OF THE UNITED STATES ECONOMY FOR 1929, 1939 AND 1949 EXPRESSED IN TERMS OF 1939 DOLLARS.

(MILLIONS OF DOLLARS)

Sectors producing the output	Year	Sectors consuming the output (inputs)						
		Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government	Household (consumption)	Net outputs
Primary agricultural production	1929	----	3,946	1,686	769	----	486	6,887
	1939	----	3,882	1,753	433	763	448	7,279
	1949	----	3,889	2,452	603	177	202	7,324
Secondary agricultural production	1929	293	----	3,555	11	----	602	4,462
	1939	373	----	4,464	6	----	760	5,605
	1949	271	----	5,964	15	----	670	6,921
Industry and services	1929	1,919	972	----	3,113	3,160	61,395	70,561
	1939	1,865	910	----	2,678	5,860	65,537	76,850
	1949	3,641	1,281	----	5,259	9,929	87,274	107,385
Foreign trade (imports)	1929	----	----	1,863	----	64	821	2,749
	1939	----	----	1,522	----	69	684	2,276
	1949	----	----	2,039	----	1,824	874	4,738
Government	1929	481	38	7,070	305	----	2,259	10,156
	1939	425	25	9,242	604	----	3,036	13,334
	1949	447	32	18,418	403	----	12,558	31,860

TABLE 10. TECHNICAL INPUT COEFFICIENTS AND CONSUMPTION OF THE UNITED STATES ECONOMY FOR 1929, 1939 AND 1949 EXPRESSED IN TERMS OF 1939 DOLLARS.

Sectors producing the output	Year	Sectors consuming outputs (inputs)					
		Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade (exports)	Government	Household (consumption) millions of dollars
Primary agricultural production	1929	----	0.884	0.024	0.280	----	486
	1939	----	0.692	0.023	0.190	0.057	448
	1949	----	0.562	0.023	0.127	0.006	202
Secondary agricultural production	1929	0.043	----	0.050	0.004	----	602
	1939	0.051	----	0.058	0.003	----	760
	1949	0.037	----	0.056	0.003	----	671
Industry and services	1929	0.279	0.218	----	1.132	0.311	61,395
	1939	0.256	0.162	----	1.177	0.439	65,537
	1949	0.497	0.185	----	1.110	0.312	87,274
Foreign trade (exports)	1929	----	----	0.026	----	0.006	821
	1939	----	----	0.020	----	0.005	684
	1949	----	----	0.019	----	0.057	874
Government	1929	0.070	0.009	0.100	0.111	----	2,259
	1939	0.058	0.005	0.120	0.265	----	3,036
	1949	0.061	0.005	0.172	0.085	----	3,693

production relationships over time. In table 10, the input coefficient of industry and services products to primary agricultural production increased from 0.279 in 1929 to 0.497 in 1949. In other words, the input from industrial sectors, used per unit of output by primary agriculture, nearly doubled in 20 years. This increase is mainly the result of technological changes in crop production. The change from horsepower to mechanical power particularly increased the coefficient; the increased use of commercial fertilizer has had the same effect. In absolute terms, the flow of inputs to primary agriculture from industry increased from 1,919 millions to 3,641 millions. This represents nearly a doubling of the estimated physical flow from industry to primary agriculture.

Net output of secondary agriculture increased over 30 percent from 1929 to 1949 (table 9). The increase in secondary production was more than proportional to the increase in primary production, a process possible because of more efficient rations in livestock production and use of feeds for livestock previously utilized for work animals. The input coefficient of primary agricultural products (feeds) to secondary agricultural production declined from 0.884 to 0.562, a decline of about 35 percent. Less feed was required to produce 1 dollar's worth of livestock product in 1949 than in 1929.

The input coefficients "of industry to secondary agriculture" are in the opposite direction from those for "industry to primary agriculture." Whereas changes in techniques caused a large increase in the input from industry for a unit of output in primary agriculture, the absolute flow of industrial product to secondary agriculture increased by less than 10 percent, and the input coefficient actually declined. The technical advances and changing resource combinations in secondary agriculture, therefore, have had a relatively small dependence on industry. Some techniques, such as antibiotics, are new materials which must flow from industry to secondary agricultural production. However, innovations such as these lower the requirement, per unit of output, of other industrial products such as protein feeds and other feed supplements.

TABLE 11. INTERDEPENDENCE COEFFICIENTS FOR 1929, 1939 AND 1949 EXPRESSED IN 1939 DOLLARS.

Sectors producing the outputs	Year	Sectors consuming the outputs: Primary agricultural production	Secondary agricultural production	Industry and services	Foreign trade	Government
Primary agricultural production	1929	1.06765	0.96359	0.08776	0.40526	0.02988
	1939	1.06679	0.75341	0.08686	0.33430	0.10095
	1949	1.05925	0.66548	0.07540	0.23711	0.04351
Secondary agricultural production	1929	0.06361	1.06945	0.05975	0.09192	0.01917
	1939	0.07450	1.06311	0.06989	0.10898	0.03554
	1949	0.06736	1.05383	0.06639	0.08874	0.02618
Industry and services	1929	0.35777	0.56133	1.10922	1.39769	0.35400
	1939	0.34039	0.42089	1.12527	1.52864	0.01589
	1949	0.56493	0.56178	1.14734	1.39158	0.44068
Foreign trade	1929	0.01016	0.01568	0.03007	1.03872	0.01594
	1939	0.00729	0.00887	0.02305	1.03276	0.01589
	1949	0.01978	0.01869	0.03348	1.04598	0.07045
Government	1929	0.11214	0.13460	0.12114	0.28474	1.03950
	1939	0.10560	0.10192	0.14685	0.47796	1.07305
	1949	0.15798	0.14000	0.20416	0.34142	1.08414

AGGREGATE TECHNICAL CHANGES WITHIN A SECTOR

Relative changes in the flows or input coefficients over time reflect both changes in techniques and changes in the combination of factors used in producing the net output of a particular sector. The aggregate effect of technical changes in the sectors can be observed to some extent by predicting a future output from past relationships. The net outputs required to produce a given final bill of goods can be predicted from the interdependence coefficients and the final bill of goods. The interdependence coefficients, expressed in terms of 1939 dollars, for the 3 years are obtained by solving the basic systems of equations (obtained from the technical production coefficients in table 10) and are given in table 11.[12]

Observing aggregate technical change over time through input-output analysis requires a "backward prediction" of the net outputs (22, p. 153). This procedure is used for table 12. We predict 1929 output using 1939 coefficients; 1939 output is predicted with 1949 coefficients. If the predicted output for one of these years is the same as actual output, no technical change has taken place; a large difference denotes great technical change. The 1939 bill of goods (household consumption) and the 1949 interdependence coefficients, expressed in 1939 dollars, are used to predict the 1939 net outputs. To observe changes in the earlier period, the 1929 bill of goods and the 1939 interdependence coefficients are used to predict the 1929 net outputs.

Table 12 shows the actual and predicted 1939 and 1929 net outputs. The two sets of net outputs for 1929 are similar, except for secondary agricultural production. It is concluded that little aggregate technical change occurred during the 1929-39 period, except in secondary agricultural production; the coefficients of the later year were reasonably accurate in predicting outputs of the earlier year for all sectors but secondary agriculture. In table 12 actual net output of secondary agricultural production increased from 4.4 billion dollars to 5.6 billion over the period 1929 to 1939. Over the same period, actual flows from primary agriculture and industry and services to secondary agriculture decreased. This change, a greater quantity of output from a smaller quantity of input, in the same period (table 9) indicates the degree of technological progress in the period. A comparison of the actual and predicted net outputs (table 12) for 1939 also indicates large technological progress in all sectors over the 1939-49 period. In other words, if the actual inputs of 1939 and the production coefficients of 1949 are used to predict the 1939 output, the predicted output is greater than

[12] The interdependence coefficients expressed in 1939 dollars were obtained by transforming the interdependence coefficients expressed in terms of 1949 and 1929 dollars. A basic system of equations, similar to the one outlined for 1949, was set up for each year, and the system was solved for the interdependence coefficients. A transformation was then performed to obtain the coefficients expressed in 1939 dollars. The adjusted interdependence coefficients are those given in table 11.

TABLE 12. PREDICTION OF THE ADJUSTED NET OUTPUTS FOR 1929 AND 1939 FROM ADJUSTED INTERDEPENDENCE COEFFICIENTS FOR 1939 AND 1949.

(THOUSANDS OF DOLLARS)

Sector	1939 net output	Predicted 1939 net output from 1939 bill of goods and 1949 adjusted coefficients	1929 adjusted net output	Predicted 1929 net output from 1929 adjusted bill of goods and 1939 coefficients
Primary agricultural production	7,279,815	6,217,511	6,887,985	6,808,042
Secondary agricultural production	5,605,189	5,823,253	4,462,328	5,137,367
Industry and services	76,850,954	78,165,148	70,561,333	71,940,738
Foreign trade	2,276,098	3,147,284	2,276,945	2,308,205
Government	13,334,000	17,082,701	10,156,162	11,946,298

the actual output; hence, technical change has occurred.

LIMITATIONS OF THE INPUT-OUTPUT MODEL FOR AGRICULTURE

In this study we have attempted to show the adaptability and application of the Leontief input-output analysis to agricultural production. While the data are somewhat meager, the method does have important uses in analyzing the agricultural economy. There are, of course, certain limitations of the Leontief input-output analysis. These limitations are applicable when the procedure is used for agriculture or other industries. This section deals with some of the major limitations as they relate to the agricultural economy.

AGGREGATION

The aggregation problem is encountered in all macro-economic studies and is also in this study which deals with activities of the whole economy. It is impracticable to include all relevant, single variables of a complex economy in a single model. Therefore, it is necessary to combine similar activities and reduce the size of the model (number of equations) to a manageable level.

Breaking the economy down into a smaller number number of relevant sectors is a difficult task. Since statistical procedures are not available for classifying inputs and outputs, the judgment and experience of the investigator must be used to choose the model and select the activities to be combined. Tintner (28, pp. 102-114) uses the method of principal components as a tool for dealing with aggregation of several variables into a few principal components. Leontief (22, p. 207) suggests that, after the parameters are estimated from the input-output study, a controlled experiment or direct observation of the economy might be used to test the validity of the estimates. However, the controlled experiment is not practical, and direct observation of the economy is questionable. Even if it were possible, past relationships would still be used for estimating quantities of the future.

If the data for empirical study are aggregated into a model of n_1 sectors and alternately into a model of n_2 sectors, the estimates of the parameters will not be the same for all corresponding sectors. Hence, the question of which model is the most reliable or acceptable for making inferences concerning the interdependence of the sectors is important. If primary and secondary agriculture are used in each of two models while alternative aggregations are used for the rest of the economy, the interdependence coefficients of agricultural and other sectors will not be the same. (They might be similar if the sum of the coefficients were calculated for the relevant industrial sectors.)

COMPUTATIONS

Both methodology and obtaining funds are problems which make computations difficult. Computations are very costly where large models are employed. The model can become so large that computational equipment is not available to the research organization. The 5×5 model used in this study was handled with the ordinary 10-bank electric calculator. Beyond the 5×5 model, the IBM calculator must be used; it reaches its limit at about a 15×15 model. Electronic computers represent the only feasible method of performing the larger calculations.

Mathematical computations (inverting matrices) for input-output analysis cause a multiplication of the errors present in the data. The larger the model, the more influencial these computational errors become. This limitation itself restricts the input-output analysis to relatively small models and to broad aggregations.

ASSUMPTION OF LINEARITY

The literature dealing with the Leontief input-output analysis has emphasized the limitations of the assumption of linear production functions. The nondecreasing production function (homogeneous production functions of degree one) are, in some cases, unrealistic. This report does not attempt to resolve the assumption of linearity or to reject the method which employs it. It is primarily concerned with input-output coefficients in the agricultural sectors. However, discussions of the validity of linearity in other sectors of the economy cannot be ignored in considering the application of input-out analysis.

Assumptions of linearity of production are not new to research in agricultural production. They have been classical tools in farm management and other research. Constant returns to scale have been assumed in the commonly used technique of imputing returns to factors of production. Generally, market rates of return are imputed to all factors except the one being studied. A residual of the total product is used to measure the productivity of the factor (13, p. 776). These and other traditional methods of analyzing farm business or survey records imply constant production coefficients. Budgeting, employed by many agricultural economists in determining an optimum combination of farm resources, is based on the assumption of linear production relationships. These conventions do not justify adoption of input-output analysis which also assumes linear relationships. However, the technique presented here is no more subject to error than classical analyses which employ the assumption of linearity.

Many aspects of agricultural production can be described by linear relations. Linearity is also found where resource inputs can be or are increased by the same proportions. In producing an acre of corn under a given technique, if all resources can be duplicated in every fashion, output also might be duplicated. Similarly, a single animal, fed under a given technique, can be duplicated by the same technical combination of inputs. A linear production function then exists even if component units of net output result from small individual production processes and resources which, if increased by themselves, are not linear.

However, one of the most serious limitations of linear assumptions in input-output analysis is this: When change in the level of net output in a sector is assumed, it must also be assumed that resources

to produce the net output are available and can be drawn into the sector. This is unrealistic in primary agriculture (and partly so in secondary agriculture) where the quantity of land is fixed and capital is not always available to the individual producer. If primary agriculture increases, and linearity is retained, additional land must also be available to combine with the additional labor and resources from other sectors. If land is not available, increased production must be brought about by using more labor and capital resources on the fixed acres already in use. Fixed production coefficients could not be expected under this situation, except that they might be approximated in a time sense, as technological improvement lowers the input-output coefficient.

STRUCTURE OF MODEL

The flow model and the classification of inputs used in this study represent only one alternative of the many which might be used. Additional studies are needed which use other models. Limitations may exist for the classification procedures used in this study. It can be questioned whether subsidy payments to agriculture should be used along with the value of crops produced as part of the output for primary agriculture. Measurement of government services to the various sectors by the amount of tax revenues also may be questionable. Perhaps part of the services attributed as flowing either to or from foreign trade should be allocated to industry. Under an alternative formulation, goods and services sold abroad might best be allocated to the industrial sectors from which they originate. Similarly, income taxes paid by individuals and families may not truly reflect the services of the government sector flowing to households. However, these classifications and aggregations were employed in this study as logical for the purpose of the analysis. Alternative formulations need to be tested in subsequent studies. Detail on the classification and aggregation of inputs and outputs of the various sectors are provided in order that the coefficients obtained in this study may be compared to those obtained under alternative input-output models.

SUMMARY

1. This study applies a Leontief-type, input-output analysis to a model of five economic sectors where emphasis is on interdependence of (a) primary with secondary agriculture and (b) agricultural sectors with the industrial sectors of the economy. Detailed analysis is made of input coefficients and interdependence coefficients for the year 1949; similar analysis is made for the years 1949, 1939 and 1929 to allow prediction of change in the coefficients in agriculture.

2. The coefficients derived in this study suggest the nature of the interdependence of agriculture with other major sectors of the national economy. They show direct and indirect changes expected in agriculture as postulated changes take place in population and national consumption (the "final bill of goods").

3. For 1949, the input coefficients of primary agricultural products flowing to other sectors were: 0.032 for secondary agriculture, 0.336 for industry, 0.356 for labor and 0.035 for government. For flows from secondary agriculture to other sectors, the input coefficients were: 0.652 for primary agriculture, 0.145 for industry, 0.280 for labor and 0.003 for government. A change by "1 dollar's worth" in primary agriculture would have necessitated increased flows from other sectors of the magnitudes expressed first; the same magnitudes of change in secondary agriculture would have required increased flows from the other sectors by the amounts mentioned second. A 10-percent change in output of secondary agriculture would have required a 5.3-percent change in primary agricultural output but only a 0.12-percent change in industrial output; a change of 10 percent in primary agriculture would have required a change of only 0.39 percent in secondary agricultural output and 0.34 percent in industrial output.

4. The interdependence coefficients for primary agriculture are 0.06 with secondary agriculture and 0.42 with industry. For secondary agriculture, they are 0.71 with primary agriculture and 0.44 with industry. These coefficients show the interdependence between the final bill of goods (household consumption) and the level of output of the various sectors. Hence, an increase in "demand" for primary agricultural production of "1 dollar" would require a 0.06-dollar increase in output of secondary agriculture and a 0.42 increase in output of industry. The same increase in "demand" for industrial products would increase output in primary agriculture by only 0.10 dollar and in secondary agriculture by only 0.08 dollar. Industry depends little on agriculture, but agriculture depends heavily on industry for increases in output.

5. Analysis of data from 1929 to 1949 shows an increase in interdependence coefficients of primary agriculture on industry from 0.36 to 0.56. In other words, the dependence of primary agriculture on industry has increased with time. The interdependence coefficient for secondary agriculture on industry remained constant at 0.56 over the same period. The coefficient of secondary agriculture on primary agriculture decreased from 0.96 to 0.66. These changes express technological improvement which has caused crop production to require a greater outlay for industrial products, such as fertilizer and machinery, and has caused secondary production to require smaller feed inputs for each unit of livestock product.

6. Limitations of input-output analysis applied to agriculture involve the assumptions of linear functions and fixed coefficients, the process of aggregation and the selection of a particular model.

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