*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

# This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

# Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

# PROBLEMS AND APPLICATIONS OF A CALIFORNIA INTERINDUSTRY MODEL

By

William E. Martin and Harold O. Carter

University of California, Davis

California is in a state of rapid economic development. Efforts to understand and guide this development are being made by leaders in government, business, and agriculture. California's complex economic structure, however, makes difficult the formulation of rational programs of action and/or the estimation of the effects of alternative courses of action. The economist interested in attacking these difficulties has many alternative research procedures to choose from. Yet, most procedures do not specifically consider the entire economy as an interrelated unit. This paper discusses one research approach--interindustry analysis--that allows quantitative estimates of the interrelationships of a complete economy and, when applied to the California economy, provides a framework for measuring the impact of alternative public and private investment decisions.

This paper aims not at presenting the results of a completed study but rather at relating some of the problems and possible applications of this approach. Moreover, since we view this research as preliminary but potentially long-range, suggestions and comments are welcomed. The paper is organized as follows: (1) previous work and basic input-output theory are reviewed briefly; (2) major problems encountered in constructing the California model are related; (3) some preliminary empirical applications of the model are made; and (4) anticipated future work and modifications are discussed.

## Previous Work

Pioneering studies were made by Leontief for the American economy for 1929 and 1939.1/ In the United States, however, the major input-output study has been the 450 sector model prepared by the Bureau of Labor Statistics for the year 1947.2/ Other national input-output studies have been made for foreign countries, including the United Kingdom, Japan, Canada, and Italy.

---

1/ Leontief, Wassily, *The Structure of the American Economy, 1919-1939*, 2nd. ed., Oxford University Press, New York, N. Y., 1951.

2/ Evans, W. Duane, and Marvin Hoffenberg, *The Interindustry Relations Study for 1947*, Division of Interindustry Economics, Bureau of Labor Statistics, U. S. Department of Labor, 26 December 1950.

Regional models constructed for the U. S. include work by Moses, at Harvard,[3] the Moore and Peterson models for Utah and for California,[4] the University of Maryland's model of Maryland,[5] Hoch's Chicago Area Transportation Study,[6] Hirsh's study of the St. Louis area,[7] and Iowa State's series of models by Heady, Peterson,[8] Schnittker,[9] and Carter.[10] All of these models except those from Iowa State were for the year 1947, and where data could not be obtained directly, adjusted the 1947 U. S. table for geographic differences only. Technical coefficients were usually assumed to be constant throughout the United States, but final demand was modified where possible.

The Iowa State models emphasized agriculture, as does the present California model. Peterson had 5 sector models for 1929, 1939, and 1949. Schnittker expanded on Peterson's work in constructing a regional model of agriculture for 1949. Carter constructed a 10-agricultural-region model for 1954.

## What is Input-Output Analysis?

An input-output model is simply a set of linear equations describing the inter-sector flows of goods and services. Three separate stages of

---

3/ Moses, Leon N., "The Stability of Interregional Trading Patterns and Input-Output Analysis," American Economics Review, Vol. 45, December 1955.

4/ Moore, Frederick T. and James W. Peterson, "An Interindustry Model of Utah," Review of Economics and Statistics, Vol. XXXVIII, November 1955.

________. A 56 sector interindustry table of California for 1947, unpublished.

5/ University of Maryland, Bureau of Business and Economic Research, A Regional Interindustry Study of Maryland. Vol. 8, No. 2 of a series on "Studies in Business and Economics" under the direction of John H. Cumberland, Sept. 1954.

6/ Hoch, Irving, Chicago Area Transportation Study: Forecasting Economic Activity for the Chicago Region, May 1959.

7/ Hirsh, Werner A., "Interindustry Relations of a Metropolitan Area," The Review of Economics and Statistics, Vol. XLI, November 1959.

8/ Peterson, G. A. and Earl O. Heady, Applications of Input-Output Analysis to a Simple Model Emphasizing Agriculture, Iowa Agr. Expt. Sta. Bul. 427, 1955.

9/ Schnittker, John Alvin and Earl O. Heady, Application of Input-Output Analysis to a Regional Model Emphasizing Agriculture, Iowa Agr. Expt. Sta. Res. Bul. 454, 1958.

10/ Carter, Harold O. and Earl O. Heady, An Input-Output Analysis Emphasizing Regional and Commodity Sectors of Agriculture, Iowa Agr. Expt. Sta. Res. Bul. 469, 1959.

analysis are involved. In the first stage, a "flow" table is constructed in which the output of each sector of an economy is allocated to every sector that uses this output. For this stage of analysis, physical units could be used, but, to facilitate later analysis and to aggregate into a workable number of sectors, all flows are converted to money units, usually the value to the producer.[11] A complete "accounting" of the flows of all goods and services from one sector to another results. This system may be described mathematically as in Appendix note 1 and is illustrated in tabular form in Table 1.

A row of this initial matrix sums to the total output of that particular sector, whereas a column shows the individual inputs to the sector. Since each sector is both a producer and a consumer, the number of rows equals the number of columns, and the sums of corresponding rows and columns are equal. That is, the value of output of an industry is assumed to be equal to the value of its inputs.

In the second stage, a table of technical coefficients is developed.[12] Here the basic assumption of input-output analysis is involved. That is, a linear relationship is assumed to exist between the purchases of an endogenous sector and the level of output of that sector, as provided in equation (1):

$$x_{ij} = a_{ij} X_j - c_{ij} \qquad (1)$$

in which $a_{ij}$ and $c_{ij}$ are constants, $x_{ij}$ is the amount of output of sector i purchased by sector j, and $X_j$ is the output of sector j.[13] To facilitate empirical work, $c_{ij}$ is assumed to be zero. The technical coefficient $a_{ij}$ is thus derived from the ratio

$$\frac{x_{ij}}{X_j}$$

which is the purchase of output of industry i by industry j, divided by the gross output of industry j. Each sector of the endogenous part of the model is now described in terms of a common unit: dollar inputs per dollar of output. The <u>direct</u> dependence of each sector on any other sector is now quantifiable (<u>under</u> the assumption stated).

---

11/ Some studies have been constructed on the basis of value to the purchaser. In either case, the margin (the difference between the producer's and purchaser's value) is allocated from sectors such as "Trade" or "Transportation" which do not give or receive flows of physical goods in the inter-industry sense. For an example of a study using purchaser's value see Chenery and Clark's study of the Italian Economy; Mutual Security Agency, Special Mission to Italy for Economic Cooperation, Rome, Italy. <u>The Structure and Growth of the Italian Economy</u>, Rome, Italy, Mutual Security Agency, 1953.

12/ Illustrated for the California model in Table 3.

13/ See Appendix note 2. The validity of this assumption is discussed in many papers: see for example, Cameron, Burgess, "The Production Function in Leontief Models," <u>Review of Economic Studies</u>, Vol. 20. 1953.

The third, and perhaps most useful, table summarizes not only the direct dependence but also the indirect and circular effects of one sector on another.[14] Each interdependence coefficient shows the output required from sector i per dollar of output of sector j delivered to final demand (the ultimate user). The interdependence coefficients are computed directly from the second table, being the inverse of the difference between an identity matrix and the matrix of technical coefficients.[15] Levels of final demand may be specified, and the corresponding outputs needed to satisfy this demand are easily obtained. The unique feature of the interdependence matrix is that direct, indirect, and circular effects are summarized. For instance, an increase in the level of demand for alcohol would imply an increase in the level of demand for corn, which would imply an increase in demand for farm machinery,[16] which would imply an increase in demand for industrial chemicals, which would imply an increase in demand for alcohol, and so on.

## The Regional Input-Output Model

The above describes the general model. A regional model requires only the addition of another dimension--space or location; that is, the imports and exports of the region must be specifically recognized. The technical coefficients of the region in question will then show only regionally produced inputs per unit of output. Ideally you might wish to distribute the output of (say) a state's industry, to industry within the state, industry within other states, and industry in the rest of the world as well as to final demand in each of these regions. In other words, many systems as described above would be combined into a single system, each interrelated with the other.[17] The final demands could be changed in any region and the effects in all other regions could be noted.[18]

With limited resources available for research, however, a reasonable compromise, used in most of the other regional studies as well as in the present California model, is to consider only the interrelationships within the one region of major concern, and assign all exports, whether foreign or domestic, to final demand. Similarly, all imports into the state are aggregated, and are not analyzed in detail within the structure of the model.

---

14/ Illustrated for the California model in Table 4.

15/ See Appendix note 3 for the mathematical formulation.

16/ Other demands remaining constant.

17/ See Isard, Walter, "Interregional and Regional Input-Output Analysis: a Model of a Space Economy," *Review of Economics and Statistics*, Vol. 33, No. 4, November 1951, for a theoretical discussion of regional models.

18/ Carter has the closest empirical approximation to this model but even here, while he has 10 agricultural regions, and 10 final demand sectors for agriculture, all processing, manufacturing, service, and trade industries, and their final demands, are lumped together in one overall region. (*Op. cit.*)

## The California Model

The California model was originally conceived to examine the interdependence of the northern and southern regions of the state, similarly to the excellent study by Chenery and Clark for the Italian economy.[19] Data and time limitations forced us to be slightly less ambitious for this initial attempt. Accordingly, in this study attention is focused on the total California economy.

The decision to separate particular California industries into individual sectors or to include them in an aggregate is, unfortunately, rather arbitrary. Although an attempt is made to aggregate sectors that are homogeneous in both input structure and type of product, other important considerations are (1) the researchers' interests, (2) available funds and time (the number of cells in the table increases by the square of the number of sectors used), and (3) the form of secondary data sources. Since the main interest, here, was in the interrelationships between various agricultural sectors and the balance of the nonagricultural economy, the agricultural sectors are looked at in greater detail than any other single segment of the economy.

Specifically, the California model is constructed as follows: Inputs are distributed from ten primary agricultural sectors, 5 agricultural processing sectors, 7 manufacturing and mining sectors, 3 service sectors, and one sector including all of the "margin" (wholesale and retail trade and transportation) industries. These 26 sectors compose the endogenous part of the model.[20] Other input-supplying sectors, assumed to be exogenous in the model, include (1) scrap and byproducts, (2) federal and local governments, (3) new and maintenance construction, and (4) households. The household sector includes depreciation as well as labor and other personal income. The rest of the inputs not produced within California are distributed from a single net import sector.

Agricultural sectors, partially because of data availability, are classified on a product rather than an enterprise basis; that is, for example, a "cotton" sector is designated instead of a crop farm sector. One advantage with this classification is in the comparative simplicity of valuing and distributing each sector's output. Thus, because coverage of crop and

---

19/ Chenery and Clark, *op. cit.*

20/ The complete sector classification is as follows: (1) Meat animals and products, (2) Poultry and eggs, (3) Farm dairy products, (4) Food and feed grains, (5) Cotton, (6) Vegetables, (7) Fruit (except citrus) and nuts, (8) Citrus, (9) Forage crops, (10) Miscellaneous agriculture, (11) Grain mill products (12) Meat and poultry processing (13) Dairy products (14) Canning, preserving, freezing (15) Miscellaneous agricultural processing (16) Chemicals and fertilizers, (17) Petroleum (18) Fabricated metals and machinery (19) Aircraft (20) Primary metals (21) Other manufacturing (22) Mining (23) Utilities (24) Selected services (25) Trade and transportation (26) Unallocated.

livestock statistics was relatively complete, the 10 agricultural rows were easier to construct than any other single segment of the model.

Although the product type classification is an advantage in distributing the output of agriculture, it is a disadvantage, at least conceptually, in specifying agriculture's input structure. Costs, which were obviously joint costs, are in some cases arbitrarily divided between two or more producing sectors. Nonetheless, secondary data sources showing purchases of agriculture from industry are reasonably accessible with only minor modification and adjustments.[21]

A major problem, however, is the construction of "flows" between non-agricultural industries. The job of separating and distributing the thousands of products involved is beyond the capabilities of the individual researcher even if complete current data are available to him. Thus the input structure of the nonagricultural sectors (except the part receiving goods from agriculture) was derived using the individual technical coefficients from the 1947 U. S. table, weighted by 1954 California industry outputs.[22] For example, in the petroleum industry in 1947, purchases of internal combustion engines per dollar of output by the component industries were as listed in Column 1 of Table 2. The value of California production in 1954 for each of these component industries is listed in Column 2 of the same table. If purchases per dollar of output are multiplied by the corresponding output, an estimate of total purchases results.

Even if one is willing to accept the assumption that industry technical coefficients are uniform throughout the United States, the assumption that technical coefficients have not changed since 1947 is surely in error in varying degrees for each industry. We regard this segment of the model as the "weakest link." Further refinements, however, must await a concerted effort of state agencies and private industry in making the required information available.

As stated, the primary modification of the general model needed to construct a regional model involves specifying the imports and exports of that region. Therefore, import-export data giving detailed information on type and value of products are needed. Railroad waybill statistics (published by the Interstate Commerce Commission) are available for most products transported, but for the purposes of input-output analysis, where detailed flow data are necessary, data giving tonnages of rather heterogeneous classes of freight, are inadequate.

---

21/ The most useful sources were the working materials from the Department of Agriculture's study of agriculture's transactions with industry. Masucci, Robert H., *Dollar Volume of Agriculture's Transactions with Industry*. Agricultural Marketing Service Marketing Research Report No. 375 (Washington, December 1959).

22/ Primary sources for obtaining nonagricultural industry outputs were the 1954 Census of Manufactures, the 1954 Census of Business, and the 1954 Minerals Yearbook.

In the absence of the necessary import-export data the procedure followed in this study was to specify the total amount of a product used in the state, by both producers and consumers, compare this total with the total output produced in the state, and assume that the difference is either a net import or export, as the case may be. With imports recorded as a net relationship, and no information as to whether an industry uses domestically produced or imported inputs, a further assumption must be made in order to scale the inputs down to domestically produced goods only. A logical assumption is that each sector imports a particular class of goods in proportion to its relative use of that good. For example, if agriculture used 6 percent, nonagricultural industry 71 percent, and final demand 23 percent of the total value of chemicals and fertilizers consumed in the state, these sectors would divide the value of imports in the same proportions. Corresponding technical coefficients express the amount of a domestically produced good that is required to produce one dollar of a sector's output. A technical coefficient is also computed for the import sector, expressing the value of imports required to produce one dollar of a sector's output.

With imports and exports being computed as a residual, and a large part of the flows to producers being estimated from national technical coefficients, intensive effort was given to making estimates of final demand that would apply specifically to California. Again, data problems are formidable. Final demand includes federal and local governments, construction activities, and purchases of producer's durable as well as demand by households. Thousands of different items are purchased by each sector, and each item must be valued not at the price paid by the consumer but at the price received by the producer. Even for final demand of households, most consumer expenditure studies were not applicable.

The only complete source showing value of products purchased by households, classified by producing industry, was the 1947 Bureau of Labor Statistics study for the United States. Several adjustments were necessary to adapt this demand to California for 1954. First, 1947 U. S. demand was adjusted to 1954 prices using price inflators for personal consumption developed by the U. S. department of Commerce.[23/] This demand figure was expanded by a different factor for each sector to reflect changing consumption patterns between product classes over time. The resulting total demand was adjusted to meet a control total for U. S. consumer expenditure for 1954. An estimate of total consumer expenditure for California was then made, and the value of products demanded by United States consumers was scaled down proportionately to meet the California control total. Finally, the difference between California and U. S. consumption patterns was estimated, and the relative proportions demanded from each product class were revised.[24/]

---

23/ U. S. Department of Commerce, Office of Business Economics, National Income, 1958 Edition: a Supplement to the Survey of Current Business (Washington: Govt. Print. Off., 1958).

24/ The main source used was, Life Study of Consumer Expenditures (New York: Time, Inc., 1957), Vol. 1.

The above discussion of the model and "problems" encountered in the analysis is by no means all-inclusive; rather it is intended to be illustrative of the general type of difficulties associated with the construction of a regional input-output model working within the confines of University facilities. The purpose is not to discourage interested researchers in this area of analysis, but instead to allow recognition of the empirical as well as the conceptual limitations.

## Empirical Applications

In this section some preliminary empirical findings, based on the California Model, are provided to show the interrelations existing between agriculture and nonagricultural sectors of the state economy.[25] For ease of presentation in this paper, the 26-sector model is further aggregated to 6 sectors.

The matrix of interdependence coefficients for this highly aggregated six-sector California model is presented as Table 4. The coefficients show the amount of output required from the row sector per dollar's worth of final demand for products of the column sector. Thus, a dollar's worth of final demand for processed agricultural products from California is associated with an output of 17.28 cents worth of livestock and their products, 20.91 cents worth of crops, one dollar and 24.56 cents worth of processed agricultural products (one dollar for final demand plus 24.56 cents worth of generated internal flows), 32.03 cents worth of manufactured goods and mining products, 8.99 cents worth of services and utilities, and services from the trade and transportation sectors of 8.64 cents.

Comparisons of these figures with those of Tables 3 and 5 point up the "circularity" of the economy. For example, in Table 3 the entry in row 4, column 3, indicates that the direct inputs to the agricultural processing industry from the manufacturing and mining industries were 11.38 cents per dollar of output. The entry in Table 5, row 4 column 3, indicates that direct and indirect requirements of manufacturing and mining inputs are 25.71 cents per dollar of output from the agricultural processing industries.[26] Therefore, a dollar's worth of output of processed agricultural commodities directly generates only 11.38 cents worth of manufacturing and mining output but indirectly induces another 14.33 cents worth of manufacturing and mining products to be created. In this case the ratio of indirect to direct effects is 1.00:0.79. On the other hand, the direct generation of livestock industry output is 13.13 cents, whereas the indirect effects are only .64 of a cent --a ratio of indirect to direct of 1.00:20.52. Similar comparisons for other sectors illustrate the importance of considering both the indirect and direct effects of public or private investment decisions.

---

25/ A more comprehensive report of this research will be available about January 1, 1960.

26/ Coefficients in Table 5 are interdependence coefficients "scaled down" to reflect the effects of output changes of sectors rather than the effects of changes in final demand. This makes comparisons of the relative magnitudes of direct and indirect requirements possible.

As a further indication of the relative total effects (both direct and indirect) on the California economy resulting from a unit (one dollar) change in deliveries to final demand from individual sectors, Table 6 summarizes the "multipliers" for each of the 26 sectors of the larger California model. For example the total effect on the California economy of an additional dollar's worth of final demand for cotton may be obtained by summing the individual interdependence coefficients in the cotton column. (The 26-sector table is not presented in this paper.) This sum, 1.3491, may be termed the cotton "multiplier." For every additional dollar's worth of cotton delivered to final demand,[27] 1.3491 dollars' worth of additional output is generated within the California economy.

The poultry sector has the largest multiplier effect of the agricultural sectors. This is because the majority of the poultry industries' inputs are goods purchased from the endogenous sectors (mostly processed feeds) as compared to the relatively larger amounts of labor and land inputs that are used in agricultural sectors like fruits and vegetables.

The agricultural processing industries have the largest multiplier effects--much larger than the aircraft industry, for instance, which is such a large part of the California economy. One reason is the much lower proportion of inputs from households (labor, proprietors' income, depreciation) in the processing industries than in the aircraft industry. Another reason is that many of the aircraft industries' inputs come from the fabricated metals and machinery sector, which is a net importer. The processing industry, although also using imported machinery, purchases a large portion of its inputs from California agriculture. Facetiously, one might draw the conclusion from these results that the impact on the California economy would be greater if the defense allocation for aircraft and rockets were diverted to purchases from food-processing sectors. Other--and more pertinent--conclusions are apparent.

## Work in Progress and Anticipated Future Work

A myriad of problems and questions can be effectively considered in the structural framework of input-output analysis. This is not to say that the technique offers the means for comprehensive and penetrating analysis of all research problems, but it does provide, in addition to the more apparent advantages, a "useful context" for viewing individual endeavors. Following are some problems currently under study or anticipated for future study by the authors.

Estimation of future water requirements of California is an area of research receiving considerable attention. Input-output analysis provides a means not previously used for quantifying state water requirements. The construction and operation of a water requirements sector would be as follows.[28] Technical coefficients for water use would be developed for

---

27/ Other demands remaining constant.

28/ See Appendix note 4 for mathematical formulation.

each sector, expressing acre-feet of water required per dollar output of product. The model provides the basis for predicting individual sector outputs given a specified level of final demand (output = the matrix of interdependence coefficients times specified demand, as developed in Appendix, note 3). The water requirements per unit of output would then be multiplied times the implied outputs to obtain the total water requirement of the producing sectors for the state.[29] One advantage of this method for estimating total water requirements is that the complementary effects of each producing sector on the others are recognized. Disadvantages are apparent, however, in the restrictive assumption of constant technical coefficients. For example, the water requirement for agriculture would undoubtedly be overstated since production increases will come largely from more intensive use of present acres. Too, realistic assumptions must be made regarding the state import-export situation.

The authors also have continued interest in a further breakdown of the California economy. If, as more data become available, and with a good deal more time and money invested than in the present California model, this north-south model could be constructed, many of the economic questions raised by the California Water Plan could be examined more effectively than with present methods. The value of the analysis of aggregate water requirements, as described above, would be greatly increased with the geographic location of water needs specifically included in the model. As the model now stands, the location of water requirements is specified only vaguely (to the extent that industries are concentrated in a particular area), and flows between areas must be examined in a side problem.

Another interesting area of interdependence, and one that should prove easier to quantify, is the relationship between the basically agricultural state of Arizona and the more industrial state of California. Their sharing of the limited supply of Colorado River water emphasizes this interdependence, and because they are separated from other large agricultural and industrial complexes by distance, a regional input-output model would have great applicability.

Most improvements in the basic empirical model itself, however, must await improvements in the availability of secondary data if small research staffs are to use the input-output approach; the task of assembling data from secondary sources is sufficiently large without the added task of collecting primary data. Until such time, or until some agency with very large resources wishes to start with primary data, further empirical regional models themselves, with or without theoretical improvements, must await a new national study to use as a base, since the 1947 coefficients are rapidly becoming obsolete. Fortunately, such a study is now under way in the U. S. Department of Commerce for the year 1958, so new regional studies will be possible with more current data.

---

[29] The functional form relating sector outputs with water requirements need not be restricted to a linear homogeneous function of degree one.

Since agricultural statistics are adequate in any year, and since the plan of the Department of Commerce is to present a new national inter-industry table at intervals of no more than five years, 30/ a time series of regional models stressing agriculture could be constructed. The trend of individual and aggregate technical coefficients could then be compared over time, giving new insights into the areas of technological change and regional competition.

---

30/ U. S. Congress. Hearings before the subcommittee on economic statistics of the joint economic committee, October 29 and 30, 1957. (Washington: 1957) (85th Congress. First Session).

TABLE 1

CALIFORNIA FLOW TABLE, 1954
(all figures in thousands of dollars)*

| Producing Sectors** | Purchasing Sectors**: Secondary Agr. (Livestock) 1 | Primary Agr. (Crops) 2 | Agr. Procs. 3 | Mfg. & Mining 4 | Service & Utils. 5 | Trade & Trans. 6 | Scrap & Byprod. 7 | Net Exports 8 | Domestic Final Demand 9 | Output: Total State Output |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 Secondary Ag (Livestock) | 52688 | -- | 715013 | 21 | -- | -- | 45504 | -- | 179415 | 992641 |
| 2 Primary Ag (Crops) | 224811 | 111896 | 689049 | 9093 | -- | -- | 37325 | 543845 | 306518 | 1922537 |
| 3 Ag Processing | 170475 | 1742 | 926795 | 46748 | 471663 | 29965 | 39121 | 719025 | 3038465 | 5443999 |
| 4 Mfg. & Mining | 31149 | 258293 | 619316 | 7450736 | 1433684 | 566643 | 106710 | -- | 7652216 | 18118747 |
| 5 Ser. & Utils. | 23636 | 61691 | 203579 | 570502 | 2040518 | 1134127 | -- | 818312 | 11484242 | 16336607 |
| 6 Trade & Trans. | 61176 | 102672 | 205631 | 623375 | 630863 | 309421 | -- | 827918 | 5985547 | 8746623 |
| 7 Scrap & Byprod. | 15822 | 288 | 81278 | 124289 | 814 | -- | -- | -- | 6169 | 228660 |
| 8 Imports | 139824 | 11445 | 390768 | 339333 | 70366 | 73899 | -- | -- | 488545 | 1514180 |
| 9 Construction | 9948 | 18546 | 14978 | 47927 | 859365 | 214091 | -- | -- | 5303463 | 6468318 |
| 10 Government | 22083 | 69483 | 196088 | 863340 | 1833567 | 919142 | -- | -- | 5228869 | 9132575 |
| 11 Households | 241029 | 1286481 | 1401484 | 8043383 | 8995767 | 5499335 | -- | -- | 8239865 | 33707341 |
| Total Inputs | 992641 | 1922537 | 5443999 | 18118747 | 16336607 | 8746623 | 228660 | 2909100 | 47913314 | |

* Preliminary

** Aggregated from the 26 sector model

# TABLE 2

## Example of Computations of Intersector Flows for Nonagricultural Sectors

| Components of petroleum industry aggregate | 1947 U.S. petroleum industry purchases of engines per dollar of output (dollars) | | 1954 value of California petroleum industry production (1000's of $) | | Estimated purchases of engines by the petroleum industry in 1954 (1000's of $) |
|---|---|---|---|---|---|
| | 1 | | 2 | | 3 |
| 1. Crude petroleum | .002415 | x | 1, 123, 517 | = | 2, 713 |
| 2. Petroleum processing | .000749 | x | 1, 675, 911 | = | 1, 255 |
| 3. Coke and products | .002312 | x | 9, 820 | = | 23 |
| 4. Paving and roofing materials | .000074 | x | 51, 439 | = | 4 |
| Total inputs of internal combustion engines to the petroleum sector | | | | | 3, 995 |

## TABLE 3

California Technical Coefficients, 1954*
(dollar input of row per dollar output of column)

| Producing Sectors** | Purchasing sectors** | | | | | |
|---|---|---|---|---|---|---|
| | Secondary Agr. (livestock) | Primary Agr. (crops) | Agr. Processing | Mfg. and Mining | Services and Utilities | Trade and Transportation |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. Secondary Ag. | .0531 | -- | .1313 | -- | -- | -- |
| 2. Primary Ag. | .2265 | .0582 | .1266 | .0005 | -- | -- |
| 3. Ag. Processing | .1717 | .0009 | .1702 | .0026 | .0289 | .0034 |
| 4. Mfg. & Mining | .0314 | .1344 | .1138 | .4112 | .0878 | .0648 |
| 5. Services & Utilities | .0238 | .0321 | .0374 | .0315 | .1249 | .1297 |
| 6. Trade & Trans. | .0616 | .0534 | .0378 | .0344 | .0386 | .0354 |

* Preliminary

** Aggregated from the 26 sector model.



TABLE 4

California Interdependence Coefficients, 1954*
(dollar output of row sector required per

TABLE 4

California Interdependence Coefficients, 1954*
(dollar output of row sector required per
dollar of final demand of solumn sector)

| Producing Sectors** | Purchasing sectors** | | | | | |
|---|---|---|---|---|---|---|
| | Secondary Agr. (livestock) | Primary Agr. (crops) | Agr. Processing | Mfg. and Mining | Services and Utilities | Trade and Transportation |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. Secondary Ag. | 1.0878 | .0006 | .1728 | .0012 | .0059 | .0015 |
| 2. Primary Ag. | .2925 | 1.0627 | .2091 | .0023 | .0072 | .0019 |
| 3. Ag. Processing | .2290 | .0044 | 1.2456 | .0084 | .0424 | .0107 |
| 4. Mfg. & Mining | .1912 | .2599 | .3203 | 1.7185 | .1892 | .1420 |
| 5. Services & Utilities | .0725 | .0590 | .0899 | .0719 | 1.1600 | .1611 |
| 6. Trade & Trans. | .1044 | .0707 | .0864 | .0647 | .0556 | 1.0488 |

* Preliminary

** Aggregated from the 26 sector model.

## TABLE 5

California Adjusted Interdependence Coefficients, 1954*
(dollar output of row sector required per dollar output of column sector)

| Producing Sectors** | Purchasing sectors** Secondary Agr. (livestock) 1 | Primary Agr. (crops) 2 | Agr. Processing 3 | Mfg. and Mining 4 | Services and Utilities 5 | Trade and Transportation 6 |
|---|---|---|---|---|---|---|
| 1. Secondary Ag. | 1.0000 | .0006 | .1387 | .0007 | .0051 | .0014 |
| 2. Primary Ag. | .2689 | 1.0000 | .1679 | .0013 | .0062 | .0018 |
| 3. Ag. Processing | .2105 | .0042 | 1.0000 | .0049 | .0366 | .0102 |
| 4. Mfg. & Mining | .1758 | .2446 | .2571 | 1.0000 | .1631 | .1354 |
| 5. Services & Utilities | .0666 | .0555 | .0722 | .0418 | 1.0000 | .1536 |
| 6. Trade & Trans. | .0960 | .0665 | .0694 | .0377 | .0479 | 1.0000 |

* Preliminary

** Aggregated from the 26 sector model.

## TABLE 6

Total Multiplier Effect of a One Dollar Change in Final Demand for Products of California Industries*

| Sector No. | Sector | Multiplier |
|---|---|---|
| 1 | Meat animals and products | 1.6181 |
| 2. | Poultry | 2.3900 |
| 3. | Farm dairy products | 1.7091 |
| 4. | Grains | 1.4885 |
| 5. | Cotton | 1.3491 |
| 6. | Vegetables | 1.2894 |
| 7. | Fruit (excluding citrus) and nuts | 1.4391 |
| 8. | Citrus | 1.3438 |
| 9. | Forage | 1.3862 |
| 10. | Miscellaneous agriculture | 1.3955 |
| 11. | Grain mill products | 1.8544 |
| 12. | Meat and poultry products | 1.8182 |
| 13. | Dairy products | 2.2484 |
| 14. | Canning, preserving, freezing | 2.0779 |
| 15. | Miscellaneous agricultural processing | 1.8694 |
| 16. | Chemicals and fertilizers | 1.8669 |
| 17. | Petroleum products | 1.8119 |
| 18. | Fabricated metals and machinery | 1.6024 |
| 19. | Aircraft and parts | 1.4688 |
| 20. | Primary metals | 1.6234 |
| 21. | Other manufacturing | 1.4888 |
| 22. | Mining | 1.3564 |
| 23. | Utilities | 1.2965 |
| 24. | Selected services | 1.5653 |
| 25. | Trade and transportation | 1.3129 |
| 26. | Unallocated (mostly services) | 1.3170 |

* Preliminary

-141-

## APPENDIX

Note 1 This system may be described mathematically as below, in which $i, j = 1, 2, 3, \ldots n$,

$X_i$ is the output of sector $i$, and

$x_{ij}$ is the amount of output of sector $i$ purchased by sector $j$. $Y_i$ denotes the final demand for goods of sector $i$.

$$
\begin{array}{lllllllllllll}
X_1 & = & x_{11} & + & x_{12} & + & x_{1j} & + & \ldots & + & x_{1j} & + & Y_1 \\
X_2 & = & x_{21} & + & x_{22} & + & x_{2j} & + & \ldots & + & x_{2n} & + & Y_2 \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
X_i & = & x_{i1} & + & x_{i2} & + & x_{ij} & + & \ldots & + & x_{in} & + & Y_1 \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
X_n & = & x_{n1} & + & x_{n2} & + & x_{nj} & + & \ldots & + & x_{nn} & + & Y_n
\end{array}
$$

Note 2 $x_{ij} = a_{ij}X_j + c_{ij}$

in which $a_{ij}$ and $c_{ij}$ are constants. Since in empirical work $c_{ij}$ is assumed to be equal to zero

then $a_{ij} = \dfrac{x_{ij}}{X_j}$

# APPENDIX

Note 3 Substitute $x_{ij} = a_{ij}X_j$ in the system described under note 1 to yield:

$$
\begin{array}{ccccccccccccc}
X_i & - & a_{11}X_1 & - & a_{12}X_2 & - & a_{ij}X_j & - & \ldots & - & a_{in}X_n & = & Y_1 \\
X_2 & - & a_{21}X_1 & - & a_{22}X_2 & - & a_{2j}X_j & - & \ldots & - & a_{2n}X_n & = & Y_2 \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
X_i & - & a_{i1}X_1 & - & a_{i2}X_2 & - & a_{ij}X_j & - & \ldots & & a_{in}X_u & = & Y_i \\
\cdot & & \cdot & & \cdot & & \cdot & & & & \cdot & & \cdot \\
X_n & - & a_{ni}X_i & - & a_{n2}X_2 & - & a_{nj}X_j & - & \ldots & & a_{nn}X_n & = & Y_n
\end{array}
$$

or, in matrix notation,

$$X - AX = Y$$

Now, with specified final demands $Y_1$, $Y_2$, $Y_i$ ..., $Y_n$ and constant input-output coefficients, $a_{ij}$, the above equations can be solved for the outputs $X_1$, $X_2$, ... $X_n$ needed to supply specified deliveries to final demand.

i.e., $X = (I - A)^{-1}Y$ in which

I is an identity matrix of the same dimensions as A.

Let $(I - A) = A^*$ ; then

$$X = A^{*-1}Y$$

# APPENDIX

Note 4 Define $w_j$ = water input required in industry $j$.

Then specify a linear relationship between water requirements and sector output.

$$w_j = b_j X_j + c_j$$

Define $W$ = total water requirement in California

So $W = \sum_{j=1}^{n} w_j = \sum_{j=1}^{n} b_j X_j + \sum_{j=1}^{n} c_j$

or, in matrix notation,

$$W = b'X + k$$

Note 3 showed that, for a given final demand Y,

$$X = A^{*-1} Y$$

by substitution

$$W = b'A^{*-1} Y + k$$

Thus, for a given demand Y and given coefficients k, b', and $A^{*-1}$, total water requirements are implied.