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California Growth and Trade,  
1954-1963: An Inter-Industry Analysis  
Emphasizing Agriculture and Water  
Resource Development

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CALIFORNIA AGRICULTURAL EXPERIMENT STATION

The purpose of this study is to explore quantitatively and to evaluate the growth and trade patterns of the California economy during the decade 1954-1963. The role of agriculture and water resource development in the growth process is subject to a more detailed analysis.

The study is carried out by means of a Leontief-type dynamic input-output model of the economy. Levels of output, consumption behavior, investment activities and some important trade variables are regarded as endogenous elements of the system. Technological progress, capital movements and resource requirements and availability are explicitly incorporated in the analysis.

The estimated structural parameters are first utilized to generate time series of California's social accounts. These figures highlight the principal processes of economic growth and trade: income generation, saving and capital accumulation, exports, imports and interregional capital movements and other variables. The main structural characteristics of the economy are then summarized by the von Neumann path of maximal proportional growth, where von Neumann growth rate provides a measure of the long run growth potential of the economy, when not supported by capital imports.

The performance of the California economy is appraised relative to an efficient program of growth and trade obtained by employing dynamic linear programming techniques.

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# CALIFORNIA GROWTH AND TRADE, 1954-1963: AN INTERINDUSTRY ANALYSIS EMPHASIZING AGRICULTURE AND WATER RESOURCE DEVELOPMENT<sup>1</sup>

## INTRODUCTION

### Objectives and scope

The present study explores quantitatively the principal economic processes that took place in California during the decade 1954-1963. The rapid economic development and structural change during that period are indicated by the facts that the state's population grew from 12 million to about 18 million persons, while net product approximately rose from \$35 billion to \$60 billion (in 1954 prices).

Among the main questions the study investigated were the reason for this growth; the relationship between the state's economic development and its pattern of production and trade; the role of immigration in promoting growth; the structural changes and their effects on California economic development; and the function of technological progress and their effects on the state's pattern of trade.

Our attention was focused on the role and position of the agricultural sector in the development process. We studied how agriculture was influenced by the development; and what it contributed to the state's economic growth. In other words, how well the increased domestic demand for farm products was met by California agriculture; how much sav-

ings were generated within agriculture; and to what extent labor was released from agriculture to support growth in other sectors of the economy.

We also studied the role of land and water resources in the development process, in particular how much the scarcity of land and water resources restricted growth, and how it affected California trade.

The present study is based on a general equilibrium analysis in which the economy as a whole is considered—production, trade, consumption, and investment in all sectors are viewed as a set of interacting activities. The analysis was carried out by a comprehensive mathematical model with the aid of which the actual evolution of the California economy during the period was studied.

Because realistic economic systems tend to become enormously complex, we tried to clarify the picture of the main processes by identifying and quantifying the principal growth and trade characteristics of the economy. To this end, we explored the long-run properties of capital accumulation in California and interstate capital movements.

Finally, to find out how efficiently the California economy performed during

<sup>1</sup> Submitted for publication December 16, 1970.

the analyzed period, we developed an efficient program of capital accumulation to serve as a norm of comparison in judging the actual growth performance of the economy.

This last part of our study does not mean it was policy oriented. *Our main objective was to measure and understand rather than seek policy implications.*

### The conceptual construct

Although California economy is just another regional economy within the United States, its 1963 gross state product was surpassed only by six nations—United States, U.S.S.R., West Germany, United Kingdom, France, and Japan (Statistical Office of the United Nations, 1967). The structure of the California economy is as complex as any national economy, but presents three important differences: First, the state has no currency of its own and does not conduct an independent and deliberate monetary policy; it does not exercise an independent trade and payment policy—trade with other states being practically unhampered; and third, California residents are taxpayers and service recipients of the federal government—conceptually an external economic sector.

The mathematical model underlying the analysis is essentially a Leontief-type, dynamic input-output model—see Leontief *et al.* (1953), Chenery and Clark (1959), and Dorfman *et al.* (1958). The economy is composed of 28 producing sectors, two government sectors, one household sector, and several auxiliary sectors. The producing sectors purchase intermediate inputs from other producing sectors within the economy and from the rest of the world. They also hire the services of capital, labor, and natural resources from the household sector; in return, households receive profits, wages, and rents which together constitute the households' income. Returns on capital

are net of depreciation cost. However, the producing sectors purchase inputs for replacement purposes alone. To the extent that depreciation charges exceed replacement costs, as in a rapidly growing economy, some of the surplus generated by the producing sectors is not distributed as income.

All input-output relations are based on fixed coefficients. However, through time, some coefficients are reduced in size because of technological progress.

The government sectors raise revenue from the producing sectors (indirect taxes) and from the household sector. Indirect taxes are assumed to be proportional to the level of the sector's output; similarly, taxes collected from the household sectors are assumed to be proportional to income (income taxes). The amount of revenue collected by a government sector is regarded as its output. The purchase of goods and services by the government constitutes the inputs to this sector. The state government is assumed to pursue a policy of balanced budgets—an assumption whose validity is, at best, restricted to the long run. The federal government, on the other hand, is assumed to enjoy a surplus in its relation with California taxpayers.

California's trade with the "rest of the world" is allowed to maintain an unbalanced current account. When not compensated by unilateral transfers, the deficit creates a claim on household income by foreign lenders and vice versa. Returns on accumulated foreign investment (foreign state credit) are considered part of the household income. Insofar as the accumulated foreign investment is negative (foreign state debt), interest payments are made to foreign creditors by the household sector out of current domestic income. Capital movements are, thus, explicitly taken into account, including the substantial unilateral transfers because of immigration into the state.

The pattern of trade depends on the following type of relationship with the "rest of the world." First, some commodities, such as construction, are not tradable and are produced and consumed domestically. Second, for some exportables, California exports are exogenously given, as for instance aircrafts and parts whose export is determined mostly by the federal government. In other instances, the amount traded is less restricted and is determined by California's comparative advantage.

Our attempt to explicate California trade during the analyzed period and to derive efficient trade programs draws heavily upon the Heckscher-Ohlin trade theoretic approach (see Bhagwati, 1965). The pattern of trade is related to the state's factor endowment where dynamic elements in the form of changing factor proportions and technical progress play an important role. However, the inclusion of exogenous trade variables reflects our recognition that other forces were also effective in shaping the California pattern of trade. Among them are economies of scale, both internal and external, and even historical accidents and political relations. This may explain for instance, the central position of the aircraft industry in California exports.

Household consumption of each commodity is assumed to be a function of income alone. This bold simplification accords with our decision to ignore the consequences of changes in the price structure as is often done in similar analyses.

The process of economic growth, as conceived in the present study, is motivated by two major driving forces—an

increase in the amount of employed resources, and technological progress. The size of the labor force is assumed to be exogenously given.<sup>2</sup> A similar assumption is adopted about the availability of land and water supply. The amount of capital at any point in time is predetermined by the levels of past investment and is, thus, an endogenous variable. Four sources of domestic capital formation are distinguished: (a) household saving (the principal source of saving); (b) business saving (identified with the undistributed surplus of depreciation charges over replacement costs); (c) unilateral transfers (reference is made here to capital imported by immigrants); and (d) foreign loans (though contributing to the stock of capital goods employed in domestic production, this source does not add to California equity capital).

Capital is accumulated in the form of buildings, equipment, and inventories. The total amount of capital invested in the productive capacity of each sector constitutes a possible upper limit on the sector's output. Other constraints are determined by the amount of primary resources (including labor) available to the sector. The actual output depends on the level of effective demand for the particular commodity.

Technological progress modifies over time the input-output relations, thus making possible higher outputs with given amounts of inputs. This process is reflected in lower technical and primary resource coefficients.

The present model is a long-run model which abstracts from short-run phenomena. In particular, capital and labor co-

<sup>2</sup> The assumption concerning the autonomous nature of changes in the size of the labor force appears a bit dubious. It is not unreasonable to correlate immigration into California with the state of its economy—a high level of economic activity and low unemployment will encourage migration. However, the short-run effects of immigration on the rate of unemployment are not that obvious. Although it may accelerate economic activity, the rate of creating new jobs may fall short of the rate of growth of the labor force and, consequently, cause a rise in unemployment. Such relations are conducive to stable immigration rates.

efficients represent average long-run relationships. In the short run, the intensity of capital utilization and labor productivity may well diverge from the average long-run value. In periods of peak demand, capacity utilization rates and labor productivity may rise, while during slumps the system may slack. Short-run fluctuations may also affect saving behavior by changing the distribution of income and by setting in motion delayed adjustment processes. All these and many other short-run phenomena are ignored in the present analysis.

As the economy grows, its structure is gradually transformed. Differences in income elasticities of household demand induce changes in output composition, which is further influenced by developments in the trade pattern and by the growth rate. The latter is important for the capital good sectors which, because of the "accelerator principle," are sensitive to rates of change in output. Other structural changes are related to the process of technological progress.

Primary agricultural production, which in 1954 generated only about 5 per cent of the state income, is disaggregated into 10 separate sectors, and agricultural processing is subdivided into five producing sectors. The function of irrigation and water resource development is incorporated into the model by adding four auxiliary sectors.

### **Methodology and analytical phases**

Our model takes off from Martin and Carter's interindustry model of the California economy in 1954 (Martin and Carter, 1962). Their flow relations are first revised to account for replacement flows and for competitive imports. Water supply activities are then incorporated by adding auxiliary water supply sectors. The government and household sectors are made endogenous by treating govern-

ment as ordinary producing sectors and by representing household behavior by explicit income and consumption functions. Noncompetitive imports are made endogenous by regarding the importation of goods not produced in California as an endogenous activity in which no household income is generated. Exports and competitive imports are treated as "open end" variables.

Investment flows by industry of origin are made functions of investment in new capital capacities. The composition of capital capacity in each sector is assumed constant so that investment by industry of use can be translated into demand for capital goods, by industry of origin, via a matrix of constant coefficients.

Output flows are constrained by the amount of accumulated capital, and the analysis is carried out on the assumption that investment is induced by the need to expand productive capacities to meet demand for enlarged outputs. Martin and Carter's flow model is, thus, transformed into a flow-stock model in which economic growth proceeds through accumulation of capital.

Levels of output are further restricted by adding primary resource constraints related to the availability of labor, land, and water.

The resulting model is not determinate in the sense that at any point in time output levels are not fully determined, unless the trade pattern is somehow given.

The next phase estimates the structural parameters, based on a variety of sources, but mostly on works by Martin and Carter (1962), Zusman and Hoch (1965), and Lee (1967).

Having estimated the structural parameters, we were able to describe and analyze actual growth and trade phenomena during the decade studied. Because the general outlines of the eco-



conomic process are best summarized in a system of state accounts analogous to the national accounts, the estimated parameters and actual outputs were utilized to generate a time series of state accounts for the California economy. The figures highlight the principal processes of economic growth: income generation, saving and capital accumulation, trade and interregional capital movements, and others.

Actual trade in individual commodities was estimated as the difference between the corresponding state output and utilization figures. The evaluation of the trade pattern reveals some important shifts in California's comparative advantage and reflects the relationship between growth rates and trade behavior.

As the detailed analysis advances, the complexity of our multisectoral analysis becomes progressively evident. It turns out that the principal, long-run, structural characteristics of the capital accumulation and trade processes can be summarized in relatively few parameters. Reference is made here to the path of maximal proportional growth of the economy—the von Neumann path. The empirical use of this growth path for

international comparisons of productivity was first suggested by Weil (1967). Tsukui (1966) furnished an empirical illustration of how the von Neumann path can be employed in economic planning.<sup>3</sup> Our work is more along the lines suggested by Weil, and its main purpose is to use the von Neumann path for characterizing capital accumulation under trade. The von Neumann growth rate provides a measure of the long-run growth potential of the economy when not supported by capital imports. The contribution of imported capital to growth can thus be isolated and evaluated. This analysis is presented on pages 50 ff.

As to our appraisal of the performance of the California economy relative to an efficient program of growth and trade, the latter was formulated as a dynamic linear programming problem, with a structure similar to the efficient program of capital accumulation by Dorfman *et al.*, 1958, Chapter 12.<sup>4</sup> Besides serving as a norm of comparison, the resulting program provided insight into some problems of economic planning at the state level. The section on pages 58 ff. discusses this subject.

## A Multisectoral Linear Model of the California Economy, 1954–1963

### General formulation

The analysis of economic development and trade patterns in California during the period 1954–1963 was descriptive and normative. The model of the California economy presented in this section serves both approaches. First,

the model was formulated as a conceptual construct whose role is to provide a framework for correlating available statistical data in the analysis and explanation of observed growth and trade phenomena and to allow the derivation of important economic indicators. Second,

<sup>3</sup> The problem of maximal proportional growth under linear technologies was first introduced by von Neumann in 1937 and has since been a subject of numerous studies, particularly those concerned with the "turnpike theorem." The subject in its relation to other growth theories is surveyed by Hahn and Matthews (1965).

<sup>4</sup> A similar formulation, though on a higher level of aggregation and with different objectives in mind, was employed by Chenery and MacEwan (1966).

the model is intended to provide the basic economic relations underlying the growth process that would permit the use of optimization techniques.

The present model is multisectoral. It is based on Martin and Carter's UC classification and includes the following sectors (Martin and Carter, 1962):<sup>5</sup>

<i>Sector number</i>	<i>Sector</i>
1	Meat animals and products
2	Poultry and eggs
3	Farm dairy products
4	Food and feed grains
5	Cotton
6	Vegetables
7	Fruits and nuts (excluding citrus)
8	Citrus
9	Forage
10	Miscellaneous agriculture
11	Grain mill products
12	Meat and poultry processing
13	Dairy products
14	Canning, preserving, and freezing
15	Miscellaneous agricultural processing
16	Chemicals and fertilizers
17	Petroleum
18	Fabricated metals and machinery
19	Aircraft and parts
20	Primary metals
21	Other manufacturing
22	Mining
23	Utilities
24	Selected services
25	Trade and transportation
26	Unallocated services
27	Scrap and by-products

28	Noncompetitive imports
29-30	Construction
31	State and local government
32	Federal government
37* <sup>6</sup>	Direct household services
33-34	Inventory change
35* <sup>6</sup>	Net private capital formation
36-37	Households

To capture the main forces operating in the growth and trade processes, a fairly comprehensive model of production, consumption, investment, and trade activities is needed. Production relations are of the Leontief type and are based on fixed coefficients. The utilization of capital and primary resources is recognized. Consumption behavior is represented by a set of linear functions of income with relative prices of outputs (but not necessarily of factors) assumed constant.

The model is not closed in the sense that it does not provide a complete explanation of economic behavior. Levels of trade and investment activities constitute a set of "open end" variables. The model can be closed in a variety of ways to be discussed subsequently.

The various structural relations constituting the model are presented.

### The balance equations

The flow of goods and services in the economy is described by the following set of balance equations (expressed in matrix notation):

$$X_t + M_t = AX_t + C_t + E_t + I_t \quad (1)$$

where

<sup>5</sup> The list of sectors and their numbering is not identical with those of Martin and Carter. Some deviation was unavoidable because of aggregation, addition of auxiliary sectors, and some variation in formulation. The term UC classification is maintained, but sector numbering follows the present numbering system. For further details on sector definition, see Appendix B, UC Classification, and Martin and Carter (1962).

<sup>6</sup> UC sectors 37\* and 35\* are identified by asterisks to avoid confusion with the corresponding Martin and Carter sectors which are defined differently.

$X_{t(n \times 1)}$  = gross domestic outputs  
 (GDO)  
 $M_{t(n \times 1)}$  = imports  
 $C_{t(n \times 1)}$  = household consumptions  
 $E_{t(n \times 1)}$  = exports  
 $I_{t(n \times 1)}$  = net investments (by industry of origin)

and

$A_{(n \times n)} = [a_{ij}]$  = matrix of gross technical coefficients.

All quantities are measured in \$1,000 (1954 prices),  $n$  is 32, and  $t$  is the year index—that is,  $t$  is 1954, 1955, . . . , 1963.

The gross technical coefficient,  $a_{ij}$ , represents the amount of flow input originating in sector  $i$  required per unit output of sector  $j$ . Contrary to the standard input-output tables, the present table includes both current input flows and replacement flows required to maintain existing utilized productive capacity. Hence, equation (1) simply states the condition that total supply, consisting of domestic output plus imports, is equal to total intermediate demand (inclusive of replacement requirements) plus total final demand consisting of household consumption, domestic net investment, and exports.

## Trade activities and the balance of payments

Imports are decomposed into two components: (a) induced noncompetitive imports of goods and services not producible in California during the analyzed period and (b) competitive imports. The levels of induced imports are assumed to be proportional to the GDO. In matrix notation

$$M_t = MX_t + M_{ct} \quad (2)$$

where  $M_{ct(n \times 1)}$  denotes competitive im-

ports and  $M_{(n \times n)}$  is the matrix of propensities to import.<sup>7</sup> Because all trade variables are defined on a net basis, two corresponding elements in  $M_t$  and  $E_t$  can not assume positive values simultaneously and, in general, are nonnegative.

## The balance-of-payment identity.

The annual increment in the outstanding debt of California's residents to non-Californians consists of two principal components: (a) the deficit on current accounts—import surplus plus net interest payments to foreign creditors—and (b) unilateral capital transfers associated with the influx of immigrants into the state. The latter takes place whenever a property owner becomes a permanent resident of the state even if his property is never effectively transferred into California.

The balance-of-payment identity is then

$$\begin{aligned}
 D_t - D_{t-1} &\equiv V'MX_t + V'M_{ct} \\
 &\quad - V'E_t + rD_{t-1} \quad (3) \\
 &\quad - H_t
 \end{aligned}$$

where

$D_t$  = outstanding foreign state debt  
 at the end of year  $t$

$V_{(n \times 1)}$  = vector with all elements equal to one

$r$  = rate of interest on the foreign state debt

and

$H_t$  = unilateral capital transfer to California.

Note that  $D_t$  may be either positive or negative (in which case California's residents are net creditors).

<sup>7</sup> All noncompetitive imports are included in one sector, UC 28.

## Income and consumption relations

Two income sources are considered: (a) income originating from domestic economic activity and (b) returns on foreign investment (which may be negative).

The surplus of output over costs of current inputs and depreciation charges is assumed to be distributed to household as income. Let  $d_j$  be a constant representing the amount of depreciation charges minus replacement cost per unit output of sector  $j$ ; then, because of the constant coefficients of production and the constant prices assumptions, household income per unit output is the coefficient:

$$u_j = 1 - \sum_{i=1}^n a_{ij} - d_j.$$

Let  $U_{(n \times 1)} = (u_j)$  be the vector of income coefficients. Then, the net state income is:

$$Y_t = U'X_t - rD_{t-1}. \quad (4)$$

Consumption behavior is represented by a set of sectoral consumption functions. Per-capita consumption of each commodity is assumed to be a linear function of per-capita income or, in terms of the macrovariables,<sup>8</sup>

$$C_t = C_o N_t + CY_t \quad (5)$$

where

$$\begin{aligned} C_{o(n \times 1)} &= \text{vector of constants} \\ N_t &= \text{population size in year } t \end{aligned}$$

and

$$C_{(n \times 1)} = \text{vector of constant marginal propensities to consume.}$$

The linear Engle curves, described by equation (5), should be regarded as approximations to the nonlinear Engle curves which one expects with the present sectoral breakdown.

Because government sectors are regarded as ordinary sectors, the corresponding "consumption functions" are, in effect, direct tax functions and the "marginal propensity to consume" are marginal tax rates.

## Capital formation

Let  $I_{t(n \times 1)}^o$  be the vector of net investments in the various sectors, that is, the  $i$ th element of  $I_t^o$  represents the annual addition to the capital stock constituting the productive capacity of the  $i$ th sector, and  $K_{t(n \times 1)}$  the vector of stocks of capital constituting the sectors' productive capacities at the beginning of the year. The capital formation process is then given by

$$K_t = K_{t-1} + I_{t-1}^o \quad (6)$$

$$= K_{1954} + \sum_{q=1954}^{t-1} I_q^o.$$

Equation (6) reflects the assumption of a uniform gestation lag of one year for all sectors.

Because replacement of worn-out capital goods is already provided for in the gross interindustry flows of current inputs, the investment activity,  $I_t^o$ , represents net addition to existing capital stocks. That is, the running down of capital stocks is not permitted under the present formulation and  $I_t^o \geq 0$ .

The demand for capital goods by industry of origin, created by investment activities, is represented by the relation

<sup>8</sup> It is widely accepted that consumption is not a function of income alone. Variables like liquid assets, distribution of income, etc., are important determinants of consumption. However, because our study deals with secular relations, some of these variables, such as cash balances, may be ignored as their effects are transitory. Other variables are excluded from the analysis to preserve simplicity.

$$I_t = WI_t^o \quad (7)$$

where  $W_{(n \times n)}$  is a matrix of constant coefficients implicitly defined by equation (7).

### A reduced-form representation

By substituting equations (2), (4), (5) and (7) into the balance equation (1) and allowing for the possibility of free goods, we get

$$TX_t \geq C_o N_t - rCD_{t-1} + WI_t^o + E_t - M_{ct} \quad (8)$$

where  $T = I + M - A - CU'$ .

Equation (8) defines the reduced-form relation between the endogenous levels of output,  $X_t$ ; the open-end variables  $I_t^o$ ,  $E_t$ ,  $M_{ct}$ ; and the lagged endogenous variable  $D_{t-1}$ . This relation does not add any new independent condition to the model but is useful in certain types of analysis.

### Capital capacity constraints

It is assumed that the output of each industry is restricted by the stock of capital constituting its productive capacity. This stock of capital consists of the buildings and equipment which are ordinarily fixed in the short run as well as inventories of raw material, goods in process, and finished goods which are ordinarily variable in the short run. However, in the present model all types of capital goods, constituting a sector's productive capacity, always preserve the same proportions.

The capital capacity constraints are given by

$$LX_t \leq K_t \quad (9)$$

where  $L_{(n \times n)}$  is a diagonal matrix of capital/output coefficients.

Because we are interested in long-run growth processes, relation (9) represents the long-run optimal capital/output ratios. In reality, however, capital/output ratios are subject to substantial short-run fluctuation through variation in the intensity of utilization of the industrial capacity. The present formulation, thus, introduces rigidities not existing in the real world, thereby creating certain difficulties in the estimation and analysis of observed behavior.

### Primary resource constraints

Restrictions on output due to scarcity of primary resources are introduced into the model by the inequality

$$RX_t \leq Z_t \quad (10)$$

where  $Z_{t(p \times 1)}$  is a vector of available primary resources and  $R_{(p \times n)}$  is a matrix of resource requirements measured in resource units (employees, acres, acre-feet, etc.) per unit GDO.

Primary resources explicitly included in the analysis are: total civilian labor force, nonfarm labor force, total cropland, irrigable cropland, and various potential restrictions on water supply.

### Auxiliary industries

Our emphasis of the agricultural sectors and water resource development called for certain amplification and disaggregation of activities related to water supply and irrigation.

**Auxiliary water sectors.** To handle the water development problem, three auxiliary water-supplying sectors were defined. The first sector, UC 41, represents a low-cost water supply activity. Potential water deliveries by this sector are restricted, and by 1954 this sector was already operated at full capacity. The second water-supplying sector, UC 42, is associated with medium-cost water delivery, and only a quarter of the po-

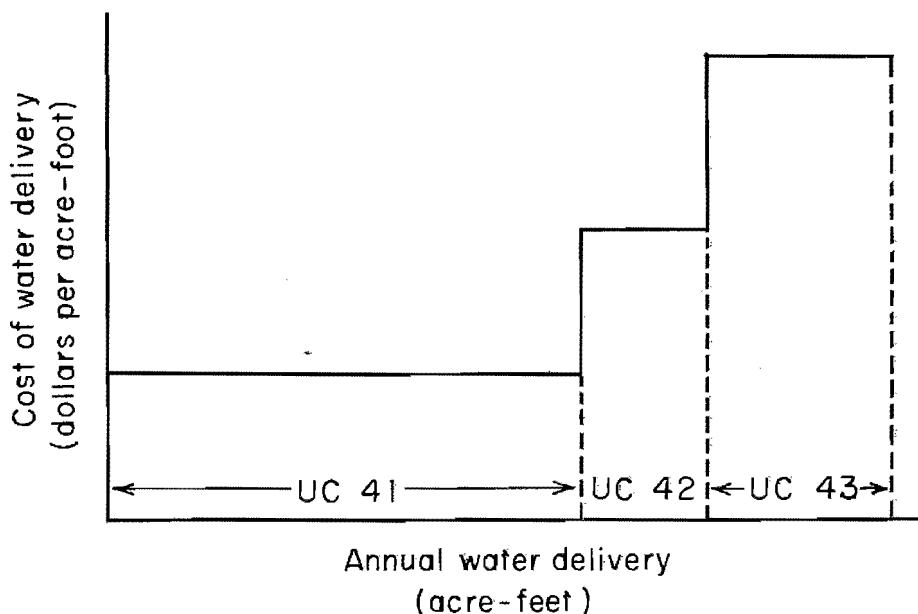


Fig. 1. Water supply cost function.

tential water resources available to this sector were actually developed by 1954. The third sector, UC 43, is a high-cost water sector that had not yet been developed at all by 1954.

A stepwise cost function of water supply may be obtained by arraying the water supply sectors in an order of increasing cost. A graphical illustration is presented in figure 1. The stepwise cost function is, in fact, an approximation to the actual cost function. In the present framework, water supply activities are treated as ordinary sectors. The matrices  $A$ ,  $L$ , and  $R$  are accordingly augmented to include the auxiliary water sectors. The columns added to  $A$ ,  $L$ , and  $R$  represent the demand by water sectors for current inputs (including replacement), capital stocks, and primary resources, respectively.

The number of rows in  $A$  is accordingly increased. One of the additional rows, the one corresponding to UC 41, now represents the water-balance equation, while the rows corresponding to

UC 42 and UC 43 are zero rows. To account for possible water deliveries by UC 42 and UC 43, the following auxiliary "water trade relation" is added.

$$M_{C, 41, t} - E_{42, t} - E_{43, t} \leq 0. \quad (11)$$

Thus, water supplies from UC 42 and UC 43 are delivered to all sectors of the economy via UC 41.

**The auxiliary irrigated land [UC 51].** Agricultural sectors UC 4 through UC 10 all include irrigated crops and utilize irrigated land. The allocation of irrigated acreage among the using sectors is easily changed over time, and investment in expanding the irrigated area is not necessarily tied to the expansion of particular sectors. A distinct irrigated land activity was, therefore, added. This activity is defined as an ordinary sector using current flow inputs (replacement flows only), capital resources, and primary resources (irrigable land). UC 51 was incorporated by adding the appropriate column to  $A$ ,  $L$ , and  $R$ , respec-

tively. Similarly, a new row was added to  $A$ , representing the irrigated land-balance equation.

### Technological progress

Technological progress is introduced into the present model by lowering over time the values of the various production coefficients.

The coefficients of  $R$  and  $A$  are lowered to reflect observed changes in primary resource productivity and more efficient utilization of flow inputs. The values of the income coefficients,  $u_i$ , are accordingly raised. Because of lack of information, no changes are introduced in the capital coefficients.

The type of technological progress considered is, thus, primary resources and flow inputs augmenting.

### Equilibrium conditions

As indicated, the set of structural relations constituting the present model is not complete, and equilibrium values of the endogenous variables are indeterminate.

Precluding the possibility of free goods and assuming the matrix  $T$  to be non-singular, it is evident from equations (3) and (8) that the system becomes determinate if the open-end variables  $I_t^o$ ,  $E_t$ , and  $M_{ct}$  are somehow determined.<sup>9</sup> Several possibilities suggest themselves. First, the values of all open-end variables may be exogenously given. Second, all trade variables may be regarded as exogenous, while investment activities are determined by means of investment functions relating rates of investment to lagged and current values

of state variables.<sup>10</sup> Third, trade functions relating levels of exports and imports to current economic activity may be introduced, thereby transforming the trade variables into endogenous variables. These three possibilities (and there may be many others) will yield purely descriptive closed models.<sup>11</sup> Alternatively, one may adopt a normative approach and look for values of the open-end variables that will maximize some objective function defined over the analytical period.

In subsequent sections, the two approaches are followed. The actual evolution of the system during the decade 1954-1963 is first traced out and analyzed. The actual economic performance is then compared to some efficient program of investment and trade.

In the following, we shall spell out explicitly the structural relations concerning investment and trade behavior underlying our analysis of the actual economic evolution.

Pure competition with perfect foresight constitutes the backbone of our conceptual construct. As such, it serves only to provide first approximations to actual behavior and is useful primarily in explaining long-run trends. Divergencies between actual behavior and that implied by the competitive model are then traced back to the deviation of the actual system from the assumed ideal.

**The investment functions.** The perfect foresight assumption implies the simplest kind of investment behavior; namely, productive capacity is expanded to meet the anticipated rise in output in the following year. This results in the

<sup>9</sup> The variables  $N_t$  and  $H_t$  are exogenously given; and  $D_{t-1}$  is a lagged endogenous and is, thus, predetermined too.

<sup>10</sup> Thus, current investment may be related to past changes in output, the rate of capacity utilization, interest rates, etc. See, for instance, Jorgenson and Stephenson (1967) and Koyck (1954).

<sup>11</sup> All contemplated investment and trade functions must, of course, be feasible. That is, outputs induced by the trade and investment activity should never violate the capital and primary resource restrictions (equations 9 and 10).

accelerator-type investment function

$$I_t^o = (LX_{t+1} - K_t)^+ \quad (12)$$

where the superscript  $+$  indicates that negative elements in  $LX_{t+1} - K_t$  are replaced by zeros.<sup>12</sup>

Equation (12) was used in estimating actual levels of investment activities from an observed time series of outputs (Appendix B, California Income and Expenditures). Equation (12) is also satisfied in the normative analysis.

**Trade behavior.** The levels of some trade variables are determined exogenously. In the present study, this was assumed to hold for some exportables but for no importables.<sup>13</sup>

The levels of other trade variables in any single year will depend on available primary resources and capital capacities as well as historical trade relations. In the longer run, however, capital capacities are variable, and investment may be channeled into industries enjoying a comparative advantage in trade. Also, interregional capital mobility adds one more dimension to the trade problem and, thus, deserves explicit recognition. In the following, we explore the problem of trade and capital movements in the framework of long-run growth and technological change. For clarity, the system will be simplified to include two productive activities—1 and 2; two factors of production—labor and capital; and a lending-borrowing activity.<sup>14</sup> We shall further assume that the analyzed econ-

omy is small relative to the "rest of the world" so that commodity prices and the interest rate are exogenously given.<sup>15</sup> The endogenous variables are the levels of the production and the lending-borrowing activities as well as the wage rate. We shall investigate the relationship between the endogenous variables, the factor endowment ratio, the technology, and the interest rate. Essentially, this is the Heckscher-Ohlin model applied to a small economy and modified to allow for capital mobility.

Let  $(a_L^i, a_K^i)$  be, respectively, the quantities of labor and capital required for the annual production of a unit of added value by the  $i$ th productive activity ( $i = 1, 2$ ). Let  $w_i$  denote the wage rate that the  $i$ th activity can afford to pay without suffering a loss. Then, given free capital movements and an exogenously determined interest rate,  $r$ , we have the relation

$$w_i \leq \frac{1 - a_K^i r}{a_L^i}. \quad (13)$$

Competition among producers in the labor market will bid up the market wage rate,  $w$ , to

$$w = \max_i \frac{1 - a_K^i r}{a_L^i}. \quad (14)$$

With the exception of the possible, but unlikely, case where  $w_1 = w_2 = w$ , only one sector will stay in production—the other sector incurring losses at the equi-

<sup>12</sup> Although equation (12) is consistent with the perfect foresight assumption, the question remains how the information concerning the required expansion in productive capacity is relayed to individual investors operating in a purely competitive system. Current market prices must somehow perform this function. Because commodity prices were assumed constant, the coordinating function is, presumably, performed by the quasi rents and factors prices alone.

<sup>13</sup> Exogenous exports are those originating in UC 5, UC 10, UC 17, UC 19, UC 22, UC 24, UC 25, and UC 26.

<sup>14</sup> In the long run, all capital goods may be aggregated and viewed as a single "malleable" good (Hahn and Matthews, 1965).

<sup>15</sup> The interest rate,  $r$ , and commodity prices are regarded as exogenously given on the assumption that California commodities and capital markets were sufficiently small in comparison to the corresponding United States markets.





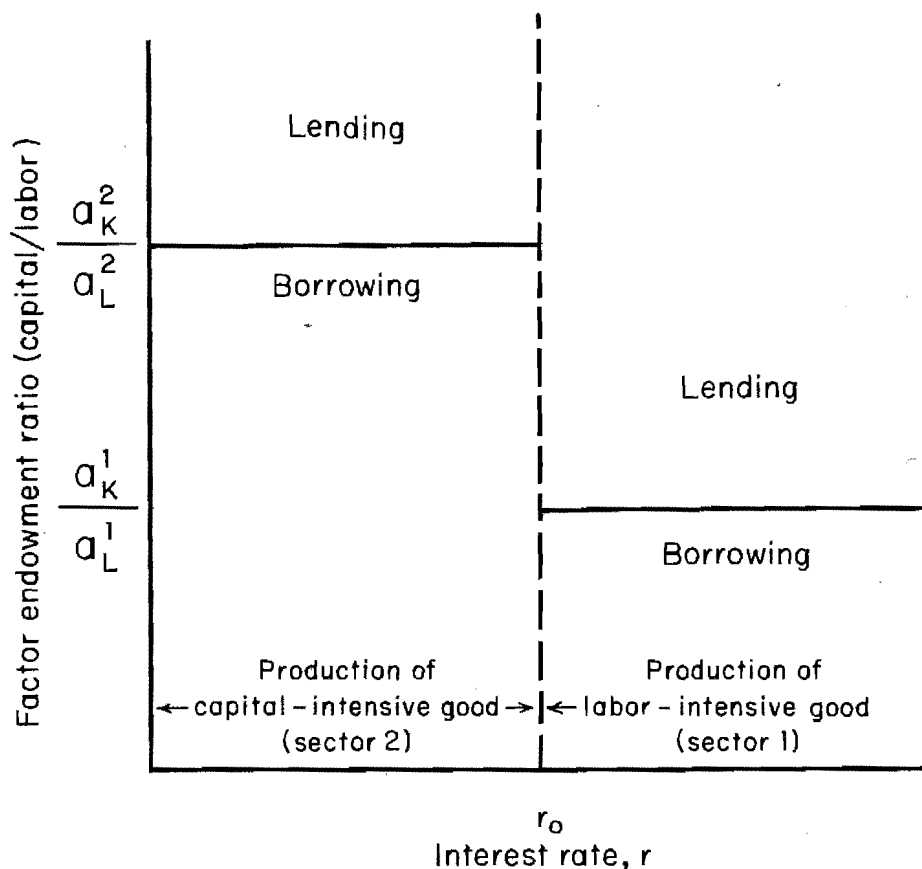


Fig. 3. Relationship between interest rate, resource-endowment ratio, and the structure of production and capital movement.

left of  $P_2$ , the capital-intensive sector will not produce. Also, since  $OZ$  is now to the right of  $OX$ , the state lends rather than borrows. The level of output and income can be derived as before. The relationship between the structure of production, capital movement, the factor-endowment ratio, and the interest rate is presented in figure 3.

Thus, for given production functions the pattern of trade depends on the

interest rate,  $r$ , alone, with the state exporting the good which it produces and importing the other good.<sup>16</sup> This is a rather unexpected result.<sup>17</sup>

When the number of resources is increased to  $n$  ( $n > 2$ ), the number of productive activities operating at positive levels may also increase up to a maximum of  $n - 1$ . Sectors producing non-tradable outputs, for which domestic demand exists, or exogenous exports will

<sup>16</sup> It is possible, though unlikely, for the state to import both goods. This may happen if the deficit in the current account is sufficiently large. A deficit is permitted under the present formulation which allows for capital movements.

<sup>17</sup> Past analyses of the effect of factor mobility on the pattern of trade dealt with somewhat different situations. In particular, neoclassical studies with a factor price equalization orientation ordinarily consider trade among big countries with identical production functions, thus assuming away the conditions conducive to our finding. See, for instance, Mundell (1957) and Kemp (1964, pp. 132-41).

always operate at a positive level. Furthermore, the resource endowment represented by the point F in figure 2 is, in effect, a *residual endowment* left over after deducting the amount of resources used by sectors producing nontradable outputs and exogenous exports.

In a growing economy, all determinants of the competitive equilibrium vary over time, thus generating a continuous shift in the equilibrium values. Three main factors should be considered in this respect: (1) the nature and rate of technological progress, (2) changes in overall factor endowment, and (3) the evolution of demand for nontradable outputs and exogenous exports. The last two factors are, in fact, related to one aspect of the problem—the change in the factor-endowment ratio used in the production of tradable goods.

We considered two types of technological change—flow-input augmenting and labor augmenting.

In terms of figure 2, the first type of technological change is represented by the sliding down of the unit isoquants  $P_1$  and  $P_2$  along the rays OX and OY, respectively. If the rate of change in the coefficients ( $a_L^i$ ,  $a_K^i$ ), say  $\epsilon$ , is identical in both sectors—that is, the coefficients become equal to ( $a_L^i(1 + \epsilon)$ ,  $a_K^i(1 + \epsilon)$ )—the capital-intensive sector will be favored by the change, since, by equation (15),  $r_o$  will now increase by a factor of  $1/1 + \epsilon$  where ordinarily  $-1 < \epsilon \leq 0$ . However, because the rays OX and OY are not shifted, no change in the amount borrowed or lent will occur unless the producing sector has been replaced. In terms of figure 3, the vertical line through  $r_o$  is shifted to the right, but the horizontal lines are unchanged.

A labor-augmenting change is represented in figure 2 by a downward shift in the unit isoquants  $P_1$  and  $P_2$ . Now an identical technological rate of change in both industries where the  $a_L^i$ 's are

changed to  $a_L^i(1 + \epsilon)$  will produce no change in  $r_o$ . This follows directly from equation (15). However, because the rays OX and OY are shifted down, the propensity to borrow will be enhanced. In terms of figure 3, a uniform labor-augmenting technology will not affect the position of the vertical line through  $r_o$  but will raise the horizontal lines defining the borders between lending and borrowing.

The effects of differential rates of technological progress can be analyzed in the same manner.

An increase in total labor force and the accumulation of capital are obvious characteristics of the growth process. However, the trade and interregional borrowing relations depend only on the residual amounts of these resources left after the resource demand by the nontradable and exogenous export sectors has been met. In general, overall capital accumulation in California has proceeded at a faster pace than the growth of labor force. This would tend to shift down the line OZ in figure 2—that is, to encourage lending and discourage borrowing. The question then arises to what extent development in nontradable outputs and exogenous exports affected this tendency. The answer is entirely in the realm of quantitative measurements and is discussed on pages 26 ff.

The preceding analysis bears important implications for the pattern of trade in the context of growth. For instance, if developments in technology and residual resource endowment are such that borrowing is encouraged, then a higher rate of domestic investment is induced. Because the construction sector, which is the main capital-good industry, produces a nontradable output, productive resources will be diverted to this sector. Consequently, domestic production of tradable consumer goods and nonconstruction capital goods will

fall off with corresponding changes in the pattern of trade. However, as we shall see later, the fundamental phenomena discussed previously are imbedded in a rather complex set of inter-

actions operating in the analyzed multi-sectoral system. An attempt at resolving some of these interactions is undertaken in subsequent sections of the study.

## The Estimated Structural Relations

### Scope and estimation procedures

The estimated values of the structural parameters, presented here, are based mainly on the 1954 input-output study by Martin and Carter (1962) and on the estimates of primary resources and capital requirements by Zusman and Hoch (1965). The estimational procedures are detailed in Appendix B.

### Gross interindustry flows and technical coefficients

Table 1 contains the gross interindustry flows,  $x_{ij}$ , of current inputs in 1954. A table entry in row  $i$ , column  $j$ , represents the amount of output of industry  $i$  purchased by industry  $j$  as current input. Replacement flows are included as current inputs. Replacement flows depend on the age distribution of existing stocks of capital goods and are thus relatively smaller the higher the economy's rate of growth. The table was adopted from Zusman and Hoch with some revisions in the estimates of replacement flows and imports (see Appendix B). The auxiliary sectors are not included in the table.

Table 2 is the matrix  $A$  of gross technical coefficients. Every element  $a_{ij}$  of  $A$  was obtained from the table of gross interindustry flows by dividing the element  $x_{ij}$  by the corresponding column total; that is,

$$a_{ij} = \frac{x_{ij}}{x_j} \quad (16)$$

The matrix  $A$  consists of coefficients related to sectors UC 1 through UC 37\*. For sectors UC 1 through UC 29-30, the set of gross technical coefficients define the production functions:

$$x_j \leq \min \left[ \frac{x_{1j}}{a_{1j}}, \frac{x_{2j}}{a_{2j}}, \dots, \frac{x_{nj}}{a_{nj}} \right] \quad \text{for } a_{ij} > 0 \quad (17)$$

$$j = 1, 2, \dots, 29-30.$$

The inequality sign in equation (17) reflects possible effective restraints on  $x_j$  by available primary resources and capital capacities.

The  $a_{ij}$  includes replacement flows which are, thus, assumed proportional to output (that is, wear and tear of capital goods is assumed proportional to their actual use and not merely to passage of time).

The coefficients  $a_{31,j}$  and  $a_{32,j}$  ( $j = 1, 2, \dots, 37^*$ ) are, in fact, rates of indirect business taxes. The coefficients  $a_{i,31}$  and  $a_{i,32}$  represent government purchase of goods and services originating in the  $i$ th sector per unit total tax revenue. Coefficients of the local and state government [UC 31] were estimated on the assumption of a balanced budget. Because in 1954 there was, in effect, a surplus budget, the balanced relations were achieved by a suitable inflation of all coefficients of the column corresponding to UC 31.<sup>18</sup>

The surplus enjoyed by the federal

<sup>18</sup> According to table 1, in 1954 the local and state government had a surplus of \$3,963,451,000 - \$3,846,830,000 = \$116,621,000.

TABLE 1  
GROSS INTERINDUSTRY FLOWS, CALIFORNIA, 1954†

UC sector of origin	UC sector of destination								
	1	2	3	4	5	6	7	8	9
	1,000 dollars								
1.....	‡								
2.....		57,363							
3.....			9,325						
4.....	15,789	26,264	8,288	9,308					
5.....					1,084				
6.....						5,562			
7.....									
8.....								2	
9.....	91,016		81,371						
10.....	107		1,976	8,109	28,939	16,206	13,260	3,507	10,391
11.....	17,366	118,768	34,343						
12.....									
13.....									
14.....									
15.....									
16.....	1,355	1,516	1,676	13,337	15,219	13,635	20,554	4,792	7,086
17.....	855	1,195	1,259	4,056	2,064	4,014	9,732	1,952	3,053
18.....	1,779	2,801	6,032	16,243	6,864	14,349	22,966	6,313	15,172
19.....									
20.....									
21.....	546	12,035	1,584	905	868	24,692	10,424	6,459	783
22.....				21	61	76	164	38	57
23.....	1,523	1,742	1,485	583	838	1,353	3,153	744	312
24.....	820	1,661	1,316	3,937	1,877	3,870	8,951	1,993	3,552
25.....	16,141	31,143	15,345	17,404	17,280	24,116	20,542	7,316	13,395
26.....	2,553	5,258	7,268	1,685	2,259	2,770	5,915	2,436	2,302
27.....	9,293	945	6,304						
28.....	113,270		10,475						
29-30.....	4,433	5,252	6,684	2,740	3,831	4,226	2,718	1,065	1,919
31.....	5,667	4,665	10,663	7,763	6,546	9,797	11,577	4,700	10,123
32.....	283	880	613	1,117	1,614	2,239	2,075	768	1,261
37*.....									
38-37.....	53,785	40,715	137,536	110,521	194,985	360,934	207,611	94,932	111,797
GDO.....	336,881	312,217	343,543	197,729	284,329	487,839	339,642	137,017	181,208

government [UC 32] in 1954 (\$287,334,-000) should, in effect, be regarded as a net import item.<sup>19</sup> Because the federal surplus was considered structural, it is represented by the positive coefficient  $a_{28, 32}$ .

The column corresponding to the net imports [UC 28] is here interpreted as including only noncompetitive imports. It is an artificial activity which imports noncompetitive goods and services (hence,  $a_{28, 28} = 1$ ) and distributes them to the other sectors of the economy.

<sup>19</sup> Because the amount of public goods provided by the federal government, which is actually an external sector, is measured by its revenue, total federal revenue in California may be regarded as imports to the state. By the same token, goods and services purchased by the federal government may be viewed as exports. Because California is a high-income state, it is not unreasonable to regard the rate of federal surplus as a structural parameter.

The coefficients in row 28 are the average propensities to import noncompetitive imports by the various sectors of the economy. The inclusion of these coefficients in the  $A$  matrix reduces the  $M$  matrix to a rather simple structure—all elements of  $M$  except  $m_{28, 28}$  vanish and  $m_{28, 28} = 1$ .

### Income-consumption relations

**Income.** Household income originating in any sector is equal to the value of output, net of the cost of current flow

TABLE 1—Continued

UC sector of origin	UC sector of destination								
	10	11	12	13	14	15	16	17	18
1,000 dollars									
1.....			562,638						
2.....			62,851	32	6	2,655			
3.....				276,821					
4.....	385	133,191				3,419	100		
5.....									
6.....					154,636	7,735			
7.....					207,818	45,384	180		
8.....					13,440				
9.....	7,062	6,732							
10.....	8,081				68,074	48,620	4,735		
11.....	138	27,741	277	198	9,418	92,816	2,343		5
12.....	500	2,406	51,016	1,941	17,200	26,682	19,934	7	
13.....		1,118	992	55,717	1,080	15,824	641		
14.....		1,067	2,217	1,014	19,614	11,254	932		
15.....	1,104	13,932	5,633	24,342	105,591	343,626	16,654	2	15
16.....	7,857	6,823	8,221	3,169	29,928	118,610	300,200	49,160	54,128
17.....	8,568	621	984	1,317	1,385	4,699	20,289	1,064,867	9,619
18.....	22,174	5,325	12,500	18,570	119,274	43,849	24,910	77,866	1,136,415
19.....									2,669
20.....							13,691	1,666	626,644
21.....	8,326	21,648	6,759	15,788	83,508	79,655	40,618	39,521	252,761
22.....	27	56				222	11,496	1,954	1,086
23.....	3,244	2,266	3,636	4,754	7,556	17,887	13,222	23,149	34,106
24.....	5,981	1,136	2,267	3,721	9,050	15,666	2,751	9,617	12,421
25.....	16,766	28,240	27,284	20,652	35,544	79,033	34,496	131,324	150,807
26.....	3,986	7,590	5,356	6,091	40,103	57,410	34,041	39,217	55,281
27.....	301	39,622	45,357				42,412	9	4,049
28.....	195		1,632			109,062	10,764	511	8,891
29-30.....	3,856	802	2,742	2,789	6,780	8,728	2,132	27,763	14,703
31.....	8,735	1,249	1,935	4,088	9,121	14,209	5,841	64,703	23,738
32.....	2,295	8,197	9,683	12,643	48,195	74,557	42,374	150,422	190,863
37.....									
36-37.....	185,747	93,936	212,200	122,032	236,020	506,041	220,518	1,178,929	1,419,333
GDO.....	294,778	403,698	1,026,189	570,629	1,221,341	1,727,143	865,274	2,860,687	3,997,514

inputs and depreciation charges. Given the price constancy and fixed coefficients assumptions, the income generated per unit output is also constant—the household income coefficient,  $u_j$ . The 1954 values of these coefficients are given in table 3. Because in a growing economy the age distribution of capital goods is younger than in a stationary economy, depreciation flows are greater than replacement flows. Consequently, household income is lower than the value added (\$30,297,000,000 income in 1954 as compared to \$31,200,000,000 value added). The difference is retained by management as internal investment funds.

Income payments on foreign loans were, by assumption, equal to zero in 1954.

**Consumption behavior.** Because price ratios are assumed constant, per-capita consumption expenditures are a function of per-capita income alone. Per-capita consumption functions are assumed to be linear in per-capita income. The estimated parameters of the per-capita consumption functions are presented in table 4.

As indicated in this section, the consumption functions associated with the government sectors are, in effect, direct tax functions.

Overall per capita consumption as a

TABLE 1—Continued

UC sector of origin	UC sector of destination								
	19	20	21	22	23	24	25	26	27
	1,000 dollars								
1.....			26						147
2.....									45,357
3.....									
4.....									
5.....			1,117						35,561
6.....									1,724
7.....									
8.....									
9.....									
10.....			2,961						40
11.....		158			5	11,513	602	1,066	1,057
12.....			2,306		688	92,207	2,049	17,493	33,163
13.....			429		417	70,824	4,623	6,263	
14.....					263	46,308	704	4,213	314
15.....		5	1,854		712	207,112	23,793	12,083	4,587
16.....	30,632	4,921	137,815	12,099	1,273	39,573	21,964	51,103	51,455
17.....	17,416	18,114	27,924	6,604	80,180	24,822	129,396	135,634	1,281
18.....	637,433	27,268	196,867	19,165	67,639	344,144	327,652	41,646	17,905
19.....	416,166					788	15,712		10,772
20.....	376,912	339,951	64,379	7,101	2,261	331	26,853	4,559	16,629
21.....	252,680	14,596	1,389,739	9,421	16,699	168,140	254,788	698,273	8,718
22.....		23,512	28,109	4,306			423		
23.....	53,908	15,827	65,507	12,160	208,045	114,735	183,900	579,982	
24.....	16,437	2,250	23,562	7,900	8,663	183,135	201,317	93,237	
25.....	98,622	41,440	215,428	10,536	49,098	280,579	362,481	359,886	
26.....	70,919	8,153	85,215	6,330	28,641	305,299	735,718	691,387	
27.....		67,111	16,367		851				
28.....	25,737	72,097	17,243	452	7,370	41	52,763	639	
29-30.....	32,696	8,575	25,402	1,151	101,368	53,935	226,375	1,098,921	
31.....	15,239	5,410	31,999	19,815	159,515	135,309	341,573	995,272	
32.....	109,473	35,597	236,724	12,796	111,795	244,741	558,851	238,030	
37*.....									
36-37.....	2,395,337	211,843	2,039,376	176,273	743,768	2,110,576	4,681,293	5,183,338	
GDO.....	4,549,607	895,828	4,610,249	305,109	1,589,221	4,434,112	8,152,630	10,213,025	228,660

function of disposable income can be computed from the information in table 4. It is:

$$c_i = .002924 + .883649 y_i^d$$

where  $c_i$  is per capita consumption expenditures on all goods and services excluding public goods (in thousands of 1954 dollars) and  $y_i^d$  is per capita disposable income (in thousands of 1954 dollars). Thus, the rate of saving out of disposable income is roughly 12 per cent, and the consumption function tends to be homogeneous as is suggested by the low value of the intercept.

The average (which is equal, by as-

sumption, to marginal) direct tax rate is about 16 per cent.

By an assumption made in the preceding section, government budgets are balanced, and public saving is always zero. This assumption is, of course, incorrect in any particular year but may be acceptable when related to long-run behavior.

### Capital/output relations

Table 5 contains the capital/output ratios for the various UC sectors.<sup>20</sup> Capital stocks include building and equipment constituting the "plants" as well as inventories of raw material,

<sup>20</sup> Entries in table 5 are identical with the diagonal elements of the  $n \times n$  matrix  $L$  mentioned on page 9.

TABLE 1—Continued

UC sector of origin	UC sector of destination								
	28†	29-30	31	32	33-34	35*	37*	36-37	GDO
	1,000 dollars								
1.....	— 247,834				2,851			3,372	336,881
2.....	1,637		450		13			187,210	312,217
3.....					2,044			9,966	343,543
4.....	— 25,384				26,369				197,729
5.....	227,897				18,670				284,329
6.....	141,307		529		— 7,572			183,918	487,839
7.....	49,766		528		658			35,308	339,642
8.....	108,603		25					14,947	137,017
9.....	— 2,958				— 2,020				181,203
10.....	44,614				4,060			31,098	294,778
11.....	— 43,653		216		433			128,890	403,698
12.....	— 190,940		4,392		— 2,246			947,391	1,026,189
13.....	— 95,350		2,263		— 1,057			506,845	570,629
14.....	826,730		1,048		18,983			286,674	1,221,341
15.....	— 178,535	322	2,097		5,692			1,136,522	1,727,143
16.....	— 510,354	116,047	6,871		959			243,650	865,274
17.....	601,456	113,461	9,857		— 568	1		554,630	2,860,687
18.....	— 3,030,426	999,369	40,374		— 11,345	1,640,462		1,130,950	3,907,514
19.....	4,103,078		17		— 2,242	1,217		1,430	4,549,607
20.....	— 901,219	313,029	53		638			2,320	895,828
21.....	— 2,647,899	957,784	38,559		— 3,019	356,200		2,488,470	4,610,249
22.....	155,609	72,242	50					7,620	306,109
23.....	— 98,179	15,468	40,750	47,475				228,590	1,589,221
24.....	552,025	139,989	15,239	10,851				3,088,970	4,434,112
25.....	— 120,922	895,550	16,037	303,264		401,283		4,552,520	8,152,630
26.....	120,000	209,224	892,825	394,704		102,429		6,280,650	10,213,025
27.....	— 10,394	6,061			372				228,660
28.....		171	924			36,808		110,470	579,515
29-30.....		1,539	1,073,466	409,830		3,311,122		21,285	6,468,318
31.....		32,329	134,013	360,374		680		1,526,803	3,963,451
32.....		86,952		16,426		13,952		3,266,036	5,479,258
37*.....								322,610	322,610
36-37.....		2,508,781	1,566,227	3,649,000		124,422	322,610		31,200,316
GDO.....	— 1,171,319	6,468,318	3,846,830	5,191,924	67,354	5,988,576	322,610	27,299,175	98,580,562

† Current inputs plus replacement flows.

‡ Blanks indicate zero or approximately zero flows.

\* Includes all trade flows and is not restricted to noncompetitive imports alone. Positive entries represent net exports; negative entries, net imports.

goods in process, and finished goods. It is assumed that these capital goods are combined in fixed proportion to form the overall capital coefficients given in table 5. The level of accumulated stocks in 1954, by industry of use, is given in table 6.

The capital/output ratio is higher in primary agricultural sectors than in manufacturing sectors. This does not necessarily mean that agriculture is more capital intensive; in fact, the intensity relations might have been reversed had the capital/value-added ratios been compared.

The high capital/output ratio in UC 26 reflects the high investment in residential construction associated with the rental subsector of UC 26.

The government sectors, UC 31 and UC 32, involve no capital stocks. Thus, investment in infrastructure, such as highways, schools, public hospitals, are regarded as investments in private sectors, such as UC 26, or as current public consumption (Martin and Carter, 1962, Part II, pp. 78 and 79). No doubt, this is a confusing convention. However, our adherence to the convention does not



TABLE 2  
GROSS TECHNICAL COEFFICIENTS: A MATRIX† CALIFORNIA, 1954

UC sector of origin	UC sector of destination										
	1	2	3	4	5	6	7	8	9	10	11
	<i>dollar per dollar</i>										
1.....											
2.....		.183728									
3.....			.027144								
4.....	.046868	.084120	.024125	.047075						.001306	.329927
5.....					.003812						
6.....						.011401					
7.....											
8.....								.000015			
9.....	.270173		.236858							.023957	.016676
10.....	.000318		.005752	.041011	.101780	.033220	.039041	.025595	.057344	.027414	
11.....	.051549	.380396	.099967							.000458	.068717
12.....										.001696	.005960
13.....											.002769
14.....											.002643
15.....										.003745	.034511
16.....	.004022	.004855	.004879	.067451	.053526	.027950	.060517	.034974	.039105	.026654	.016901
17.....	.002538	.003827	.003655	.020513	.007259	.008228	.028654	.014246	.016849	.029066	.001538
18.....	.005281	.008971	.017558	.082148	.024141	.029413	.067618	.046075	.083729	.075223	.013191
19.....											
20.....											
21.....	.002511	.038547	.004611	.004577	.003053	.050615	.030691	.047140	.004321	.028245	.053624
22.....				.000108	.002150	.000156	.000483	.000277	.000315	.000092	.000139
23.....	.004521	.005579	.004323	.002948	.003647	.002773	.009283	.005430	.001722	.011005	.005813
24.....	.002434	.005320	.003831	.019911	.006602	.007933	.026354	.014546	.019602	.020120	.002814
25.....	.047913	.090748	.044667	.089019	.080775	.049434	.060481	.053394	.073923	.056876	.069953
26.....	.007578	.016873	.021156	.008522	.007945	.005678	.017415	.017779	.012704	.013522	.018801
27.....	.027585	.003027	.018350							.001021	.098148
28.....	.336231		.030491							.000662	
29-30.....	.018159	.016822	.019456	.013857	.013474	.008663	.008003	.007773	.010590	.011385	.001987
31.....	.016822	.014942	.031038	.039261	.023023	.020082	.034086	.034302	.055806	.029632	.003094
32.....	.000840	.002838	.001784	.005649	.005677	.004590	.006109	.005605	.006959	.007785	.020305
37*											
Subtotal,											
1-37*.....	.840344	.869594	.599654	.441048	.314228	.260137	.388736	.307152	.383029	.369875	.767311
36-37.....	.159656	.130406	.400346	.558952	.685772	.739863	.611264	.692848	.616971	.630125	.232689
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

impair the analysis as long as this peculiarity is kept in mind.

The total value of capital stocks in California in 1954 amounted to \$74,144,000,000, and the overall capital/net state product ratio is about 2.13.<sup>21</sup>

Table 7 contains the fixed proportions in which capital goods are combined to create the productive capacity of the principal sectors. Because outputs are defined in producer value, the contribution of the trade and transportation sector to the capital stocks is explicitly listed.

The possibility of direct household contribution to capital formation was precluded. Households are assumed to participate in the creation of new capital capacities only through their contribution to the capital goods producing sectors.

### Replacement and depreciation

Estimates of depreciation and replacement flows in 1954 are presented in table 8. Replacement flows were added to Martin and Carter's current flow table to obtain our gross interindustry

<sup>21</sup> The value of 1954 net state product (NSP) is given in table 3.

TABLE 2—Continued

UC sector of origin	UC sector of destination										
	12	13	14	15	16	17	18	19	20	21	22
	<i>dollar per dollar</i>										
1.....	.548279									.000006	
2.....	.061247	.000056	.000005	.001537							
3.....		.485116									
4.....				.001980	.000116						
5.....										.000242	
6.....			.126612	.004478							
7.....			.170156	.025277	.000208						
8.....			.011004								
9.....											
10.....			.055737	.028151	.005472					.000642	
11.....	.000270	.000347	.007711	.053740	.002708		.000001		.000176		
12.....	.049714	.003402	.014083	.015449	.023038	.000002				.000500	
13.....	.000957	.097641	.000894	.009162	.000741					.000093	
14.....	.002160	.001777	.016059	.008516	.001077						
15.....	.005489	.042858	.086455	.198056	.019247	.000001	.000004		.000005	.000402	
16.....	.008011	.005554	.024504	.068374	.346942	.017185	.013540	.006733	.005493	.029893	.039525
17.....	.000959	.002308	.001134	.002721	.023448	.372242	.002406	.003328	.020220	.006057	.021574
18.....	.012190	.023781	.097658	.025388	.028789	.027219	.284280	.140107	.080439	.042702	.062608
19.....							.000668	.091473			
20.....					.015823	.000582	.156758	.082845	.379482	.013964	.023198
21.....	.006587	.027580	.068374	.046120	.046942	.013815	.063230	.055539	.016293	.301446	.030777
22.....				.000129	.013286	.000683	.000267		.025130	.006097	.014067
23.....	.003543	.006331	.006187	.010067	.015281	.008092	.006532	.011849	.017667	.014209	.039724
24.....	.002209	.006521	.007410	.009070	.003179	.003362	.003107	.003613	.002512	.005111	.025808
25.....	.026588	.036192	.029102	.048759	.039867	.045906	.037725	.021677	.046259	.046728	.034419
26.....	.005219	.010874	.032835	.033240	.039341	.013709	.013829	.015588	.009101	.018484	.020679
27.....	.044199				.049016	.000093	.001013		.074915	.003550	
28.....	.001590			.053145	.012440	.000179	.002224	.005657	.080481	.003740	.001477
29-30.....	.002672	.004889	.005551	.006053	.002464	.009705	.003678	.007187	.009572	.005510	.003760
31.....	.001886	.007164	.007468	.008227	.006750	.022618	.005938	.003350	.006039	.006941	.064732
32.....	.009436	.022156	.037823	.043168	.048972	.052582	.047745	.024082	.039735	.051347	.041802
37*.....											
Subtotal.....											
1-37*.....	.793215	.786145	.806753	.707007	.745147	.587886	.644946	.473507	.763523	.567865	.424150
36-37.....	.206785	.213855	.193247	.292993	.254853	.412114	.355054	.526493	.236477	.442335	.575850
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

flow table. Depreciation flows were netted out of Martin and Carter's household payment to obtain the present income flows.

Both depreciation and replacement flows are assumed to be proportional to the level of capital utilization. However, depreciation is computed on the basis of a stationary age distribution of capital stocks, whereas replacement flows are calculated on the basis of the actual age distribution of the capital goods. In a rapidly growing economy the age distribution is younger, and the rate at which capital goods are retired is lower. This

phenomenon is more pronounced the longer the life expectancy of the capital goods. Thus, 1954 replacement flows of capital goods originating in the construction sector constituted only about 37 per cent of the depreciation flows, while for capital goods originating in the fabricated metals and machinery sector this ratio amounted to 89 per cent.

Because, by assumption, the excess of depreciation charges over replacement flows is retained by firms and not distributed as household income, an important source of savings is added.<sup>22</sup> In 1954 savings generated by this source

<sup>22</sup> This source is in addition to undistributed profits which, in the present model, are included within household income and savings.

TABLE 2—Continued

UC sector of origin	UC sector of destination									
	23	24	25	26	27	28	29-30	31	32	37*
	<i>dollar per dollar</i>									
1.....					.000542					
2.....								.000117		
3.....					.198360					
4.....										
5.....					.155519					
6.....					.007540			.000137		
7.....								.000137		
8.....								.000006		
9.....										
10.....					.000175					
11.....	.000003	.002596	.000074	.000104	.004023			.000056		
12.....	.000433	.020795	.000251	.001713	.145032			.001142		
13.....	.000262	.015973	.000567	.000613				.000588		
14.....	.000165	.010444	.000086	.000413	.001373			.000272		
15.....	.000448	.046709	.002918	.001183	.020060		.000050	.000545		
16.....	.000801	.008925	.002594	.005004	.225028		.017941	.001787		
17.....	.050452	.005598	.015872	.013280	.005384		.017541	.002562		
18.....	.042561	.077613	.040190	.004078	.078304		.154502	.010496		
19.....		.000178	.001927		.047109			.000004		
20.....	.001423	.000075	.003294	.000446	.072724		.048394	.000022		
21.....	.010489	.087920	.031252	.068371	.638120		.148073	.010024		
22.....			.000052				.011169	.000013		
23.....	.130910	.025876	.022557	.056788			.002391	.010593	.008664	
24.....	.005451	.041301	.024694	.009129			.021642	.003962	.001980	
25.....	.030894	.063277	.044462	.035238			.138452	.004169	.055348	
26.....	.018022	.068852	.090243	.067697			.032346	.232094	.072086	
27.....	.000535						.000937			
28.....	.004637	.000009	.006472	.000063		1.000000	.000026	.000240	.052440	
29-30.....	.063785	.012164	.027767	.107600			.000238	.279050	.074797	
31.....	.100373	.030515	.041897	.097451			.004998	.034837	.065771	
32.....	.070346	.055195	.068624	.023307			.013443		.002998	
37*.....										
Subtotal,										
1-37*.....	.531902	.524014	.425794	.492478	1.000000	1.000000	.612143	.592853	.334034	
36-37.....	.468008	.475986	.574206	.507522			.387857	.407147	.665966	1.000000
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

† Current inputs plus replacement flows.

‡ Blanks indicate zero or approximately zero flows.

amounted to \$905,000,000 (as compared to total savings of \$3,901,000,000).<sup>23</sup> Given the prevailing accounting procedures, the underlying assumption seems quite plausible, and the replacement-depreciation relationship is, indeed, of prime importance.

### Primary resource requirement and availability

Primary resources explicitly recognized in the present study are labor, land, and water. These resources were

singled out in accordance with the particular objectives of the study. Primary resource requirements in 1954 are given in table 9; levels of available primary resources in table 10.

**Labor.** Two categories of labor are distinguished—farm labor and non-farm labor. In 1954 nonfarm wages exceeded farm wages by a substantial margin, thus encouraging migration of farm labor into nonfarm occupations. At any point in time, however, the two categories are quite distinct.

<sup>23</sup> Total savings are obtained from table 1 by subtracting the sum of column 36-37 from the sum of row 36-37.

TABLE 3  
HOUSEHOLD INCOME  
COEFFICIENTS, CALIFORNIA,  
1954†

UC sector	Income coefficient, $u_i$
1.....	.158489
2.....	.124702
3.....	.395988
4.....	.558659
5.....	.685013
6.....	.730660
7.....	.611199
8.....	.692848
9.....	.616303
10.....	.629928
11.....	.232074
12.....	.206184
13.....	.212816
14.....	.191612
15.....	.291102
16.....	.251573
17.....	.400389
18.....	.351800
19.....	.526493
20.....	.223783
21.....	.439978
22.....	.567585
23.....	.449165
24.....	.461535
25.....	.564369
26.....	.443612
29-30.....	.386604
31.....	.407147
32.....	.665966
37*.....	1.006000

† Principal sectors not listed in the table have zero income coefficients.

**Land.** Two categories of land were distinguished—total cropland in farms and irrigable land. Only 12,547,000 acres of the total cropland (13,230,000 acres) were actually cropped, and only 7,047,000 acres of irrigable land (out of 11,300,000 acres) were actually irrigated.

**Water.** Three categories of water sources are distinguished:<sup>24</sup>

(a) Sources that can be developed at a relatively low cost—mostly shallow groundwater and easily accessible surface water. All these sources were fully developed by 1954. The amount of potential water in this category constitutes an upper limit on the water-supplying sector [UC 41].

<sup>24</sup> A detailed description of the various water supply categories can be found in (Hoch and Phillips, 1970).

TABLE 4  
ESTIMATED PARAMETERS OF PER  
CAPITA CONSUMPTION FUNCTIONS:  
 $c_{it} = c_{0i} + c_{1i}y_i$ †  
CALIFORNIA, 1954

UC sector	Intercept $c_{0i}$	Marginal propensity $c_{1i}$	Income elasticity
1.....	.000277	†	
2.....	.007686	.003090	.5
3.....	.000821		
4.....			
5.....			
6.....	.012083	.001214	.2
7.....	.002320	.000233	.2
8.....	.000491	.000296	.6
9.....			
10.....		.001926	1.0
11.....	.012702	-.000851	-.2
12.....	.038896	.015637	.5
13.....	.037460	.001673	.1
14.....	.018832	.001893	.2
15.....	.074665	.007503	.2
16.....	.004001	.006454	.8
17.....	-.054670	.040279	2.2
18.....	-.027878	.048533	1.3
19.....		.000047	1.0
20.....	-.000058	.000100	1.3
21.....	.040849	.035717	.8
22.....		.000252	1.0
23.....	-.016900	.014337	1.9
24.....	-.050774	.122302	1.2
25.....		.150281	1.0
26.....	-.103236	.248793	1.2
27.....			
28.....		.003647	1.0
29-30.....		.000703	1.0
31.....		.050394	1.0
32.....		.107814	1.0
37*.....		.010650	1.0
41†.....		.004671	1.0
Sum 1 to 20-30.....			
37*.....	.002924	.743849	
Sum 31 and 32.....		.158208	
Sum 1-37*.....	.002924	.902057	

† The notation used is:

$c_{it}$  = per capita consumption of commodity  $i$  (thousand 1954 dollars).

$y_i$  = per capita income (thousand 1954 dollars).

† Blanks indicate zero.

† Water consumption is measured in acre-feet.

(b) Sources that can be developed and utilized at medium costs. Some 1,440,000 acre-feet of the potential water supply in this category were developed by 1954. The total potential supply from these sources constrains UC 42.

(c) Sources whose development and utilization is costly. Expensive surface

TABLE 5  
OVERALL CAPITAL COEFFICIENTS,  
CALIFORNIA, 1954†

UC sector	Capital coefficient
1.....	1.127466
2.....	.660290
3.....	1.398458
4.....	1.084705
5.....	1.431932
6.....	.418036
7.....	1.425531
8.....	1.692023
9.....	.946018
10.....	1.025781
11.....	.200023
12.....	.212419
13.....	.234596
14.....	.463040
15.....	.525013
16.....	.453545
17.....	.931176
18.....	.595381
19.....	.661572
20.....	.780455
21.....	.517852
22.....	.854967
23.....	3.523285
24.....	.551744
25.....	1.805112
26.....	3.268883
27.....	†
28.....	
29-30.....	.188256
31.....	
32.....	
37*.....	

† Dollars invested per dollar expansion in productive capacity. Productive capacity is expressed in terms of potential GDO.  
‡ Blanks indicate zero.

TABLE 6  
ACCUMULATED CAPITAL STOCKS  
BY USING UC SECTORS  
CALIFORNIA, 1954

UC sector	Invested capital stock
	<i>million dollars</i>
1.....	380
2.....	206
3.....	480
4.....	214
5.....	407
6.....	204
7.....	484
8.....	232
9.....	171
10.....	302
11.....	81
12.....	218
13.....	134
14.....	566
15.....	907
16.....	392
17.....	2,664
18.....	2,380
19.....	3,010
20.....	699
21.....	2,387
22.....	262
23.....	5,599
24.....	2,446
25.....	14,716
26.....	33,385
27.....	†
28.....	
29-30.....	1,218
31.....	
32.....	
37*.....	
Total.....	74,144

† Blanks indicate zero.

water development projects are included in this category, but no seawater desalination systems. No water was supplied from these sources in 1954. The potential supply from these sources represents a restraint on UC 43.

Auxiliary water supply and irrigation sectors

The role and structure of these sectors were explained on pages 9-11. Gross technical coefficients, capital output coefficients, and resource requirements by auxiliary sectors are given in table 11.

Because the output of irrigated land [UC 51] consists solely of capital services, the current flow inputs to this

sector include only replacement flows, and no labor input is involved.

The auxiliary sectors were incorporated into the general model by adding columns to the matrices A, W, L, R, and M. The columns were constructed using the estimates given in table 11.

Four rows were also added to the A matrix: (a) row UC 41 in which the water consumption coefficients of the various UC industries (table 9) were entered as row elements, (b) rows UC 42 and UC 43 with all elements equal to zero, and (c) row UC 51 in which irrigated land coefficients (table 9) were entered as row elements. The matrix R

TABLE 7  
THE INVESTMENT MATRIX, W

UC sector of origin	UC investing sector						
	1	2	3	4	5	6	7
	<i>dollar per dollar†</i>						
1.....	.879581	‡					
2.....		.287997					
3.....			.599674				
4.....	.003464	.008921	.002770	.316469			
5.....					.354020		
6.....						.024471	
7.....							.000937
8.....							
9.....	.019968		.027207				
10.....	.004863		.000660	.016669	.052444	.066161	.677805
11.....	.003810	.040342	.011482				
12.....							
13.....							
14.....							
15.....							
16.....	.000297	.000514	.000560	.027909	.027580	.055665	.120604
17.....	.000187	.000405	.000421	.008487	.003742	.016386	.067104
18.....	.010793	.175221	.066878	.448672	.389935	.402441	.264498
19.....							
20.....							
21.....	.007725	.032167	.005305		.001574	.098820	.120681
22.....				.000044	.000110	.000313	.000961
23.....				.001218	.001519	.005521	.018500
24.....				.008238	.003402	.015795	.052521
25.....	.008490	.054595	.020846	.123163	.104753	.179845	.153910
26.....				.003525	.004094	.011305	.034708
27.....	.002039	.000321	.002108				
28.....							
29-30.....	.058029	.394019	.256017	.023185	.041878	.080354	.016401
31.....	.000034	.000254	.000143	.016408	.012008	.040176	.067988
32.....	.000714	.005244	.002929	.005713	.005941	.012747	.013381
37*.....							
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

was revised accordingly. The rows of R, corresponding to water and irrigable land, have zero elements in all columns with the exception of the column corresponding to UC 41 in the water row and the column corresponding to UC 51 in the irrigable land row. Both are set equal to one.

Rows corresponding to UC 41, UC 42, UC 43, and UC 51 were also added to W. The new rows had the following nonzero elements:

$$w_{41,7} = 10.815530 \quad w_{41,8} = 5.719894$$

$$w_{51,7} = 1.652871 \quad w_{51,8} = 1.158250$$

These coefficients account for the water and irrigated land required for establishing new orchards.

The dimensions of the matrix M and the vectors C and  $c_0$  were increased in accordance with the new numbers of rows and columns. Only one nonzero element was thereby added—the propensity of households to consume water ( $c_{41} = .064671$ ).

## California Economic Growth and Trade, 1954-1963

### Outlines of the growth process

During the decade 1954-1963, the California economy experienced a fairly

high rate of growth. Thus, the NSP grew at an annual rate of about 6.1 per cent, from \$34,823,000,000 to \$59,500,-

TABLE 7—Continued

UC sector of origin	UC investing sector						
	8	9	10	11	12	13	14
	<i>dollar per dollar†</i>						
1.....					.319028		
2.....					.035637	.000008	
3.....						.059233	
4.....			.003520	.160151			
5.....							
6.....			.019531				.018529
7.....							.024902
8.....	.008826						.001611
9.....		.010405	.002401	.008094			
10.....	.072246	.063103	.357312				.008156
11.....			.000679	.179389	.000155	.000042	.001129
12.....			.001309	.002894	.193772	.000413	.002060
13.....				.001344	.000560	.112026	.000129
14.....				.001284	.001256	.000221	.392585
15.....			.002879	.016753	.003191	.005208	.012653
16.....	.098717	.043035	.011986	.008204	.004660	.000677	.003587
17.....	.040212	.018538	.006395	.000744	.000560	.000281	.000166
18.....	.242681	.527646	.415521	.284321	.189587	.449026	.267832
19.....							
20.....							
21.....	.133059	.004500	.025183	.027621	.010747	.015614	.011087
22.....	.000782	.000330	.000090	.000064			
23.....	.015326	.001894	.000886				
24.....	.041057	.021570	.003294				
25.....	.167643	.164970	.111635	.094989	.056807	.104579	.059869
26.....	.050183	.013978	.001979				
27.....			.000244	.047644	.025718		
28.....					.000927		
29-30.....	.016015	.057244	.022415	.162556	.154294	.246398	.101691
31.....	.096846	.061647	.007771	.000179	.000145	.000294	.000185
32.....	.016407	.011140	.004970	.003769	.002956	.005980	.003829
37*.....							
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

000,000. The state income during this period grew at the rate of 6.2 per cent.<sup>25</sup> California population, increasing at an annual rate of 3.9 per cent, swelled from 12,177,000 persons in 1954, to 17,902,000 in mid-1964. Of this annual growth rate, only 1.5 per cent was caused by the natural increase in population; the balance, about 2.4 per cent, by the continuous influx of immigrants attracted to California by high and rising wages, expanding job and investment opportunities, and favorable climatic conditions.

Because the increase in NSP and state

income exceeded population growth, per-capita NSP grew during the analyzed period at a rate of 2.1 per cent and per-capita state income at an annual rate of 2.3 per cent.

The main motivating force of this growth was, no doubt, the high rate of migration into California which, together with the natural growth of the state's population, provided the labor force required to support the accelerated pace of economic growth and the market for the rising output. Less obvious, perhaps, but nonetheless of primary significance, is the role of immigration

<sup>25</sup> Unless otherwise indicated, all values are expressed in terms of 1954 prices. The NSP and state income figures are based on the author's own calculations. By contrast, estimates of the U. S. Office of Business Economics (1966) imply an annual growth rate of 6.45 per cent in California's personal income.

TABLE 7—Continued

UC sector of origin	UC investing sector						
	15	16	17	18	19	20	21
	<i>dollar per dollar†</i>						
1.....							.000001
2.....	.000535						
3.....							
4.....	.000689	.000085					
5.....							.000098
6.....	.001559						
7.....	.009152	.000063					
8.....							
9.....							
10.....	.009805	.001682					.000262
11.....	.018719	.000833				.000039	
12.....	.005380	.007086					.000204
13.....	.003190	.000227					.000038
14.....	.002270	.000330					
15.....	.242304	.005920				.000001	.000164
16.....	.024717	.236918	.002703	.006397	.006888	.001231	.012223
17.....	.000948	.007212	.114455	.001137	.003905	.004489	.002477
18.....	.351453	.509277	.239545	.580772	.554824	.396124	.384449
19.....				.000315	.111545		
20.....		.007273	.101650	.074169	.084515	.129674	.007205
21.....	.022635	.042308	.060974	.032931	.063019	.018217	.228594
22.....	.000045	.004087	.000141	.000125		.005580	.002482
23.....				.000040			
24.....				.005305			
25.....	.092268	.017473	.092648	.097074	.026526	.014441	.100582
26.....				.000083			
27.....		.015078		.000478	.015049	.004056	
28.....	.021995	.003827	.000022	.001051	.005771	.017871	.001529
29-30.....	.187532	.135303	.380774	.195120	.123713	.401539	.253943
31.....	.000222	.000233	.000325	.000223	.000196	.000311	.000260
32.....	.004582	.004835	.006729	.004770	.004089	.006427	.005389
37*.....							
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

in the process of capital formation. The unilateral transfer of capital that ordinarily accompanies movement of people provided much of the capital funds required for the expansion of productive capacity. As will be demonstrated subsequently, the domestic saving rate is too low to support a rate of growth exceeding 4.5 per cent, and capital had to be imported into the state. Unilateral transfers allowed for such imports without a substantial debt formation. In fact, during most of the analyzed period California was a creditor state.

Although not explicitly measured, immigration into the state involved a considerable amount of imported human capital. To have some grasp of this

intangible, consider the amount of resources invested in educating and training people in a modern society!

However, growth did not come about solely through the increase in the amounts of labor and capital. Indeed, these factors alone could hardly account for the observed rate of growth in per-capita NSP. Much of this growth must be attributed to technological improvements which raised the productivity of labor and other primary resources at an annual rate of roughly 2.0 to 3.5 per cent. (See also pages 43-45).

The contribution of the primary resources, land and water, to the growth process was not large; thus, land utilization did not increase during the ana-



TABLE 7—Continued

UC sector of origin	UC investing sector						
	22	23	24	25	26	27	28
	<i>dollar per dollar†</i>						
1.....				.001381			
2.....				.001632			
3.....							
4.....				.000808			
5.....				.001172			
6.....				.002609			
7.....				.000512			
8.....				.000212			
9.....							
10.....				.000839			
11.....			.000770	.002662	.000002		
12.....		.000099	.006167	.009700	.000038		
13.....		.000060	.004737	.004805	.000013		
14.....		.000038	.003097	.002945	.000009		
15.....		.000103	.013854	.026713	.000026		
16.....		.001662	.002646	.008526	.000112		
17.....		.011777	.001660	.012221	.000298		
18.....	.566348	.446927	.215779	.478655	.015482		
19.....			.000052	.005439			
20.....	.003003	.073579	.000021	.009587	.000010		
21.....	.002526	.028473	.129183	.105507	.023813		
22.....	.095045	.000395		.000144			
23.....	.014918						
24.....		.013522					
25.....	.128097	.127168	.086094	.099331	.011183		
26.....					.009977		
27.....		.000123		.001766			
28.....		.001068	.000003	.000064	.000001		
29-30.....	.183307	.287481	.528192	.216834	.929722		
31.....	.000313	.006348	.000358	.000275	.000432		
32.....	.006443	.007177	.007387	.005661	.008882		
37*.....							
Total.....	1.000000	1.000000	1.000000	1.000000	1.000000		

lyzed period. In fact, total cropland dropped from 13,229,708 acres in 1954 to 11,815,368 acres in 1964.

Water supply, on the other hand, increased during the period, although at a rather slow pace—from 23.6 million acre-feet in 1954 to 27.9 million acre-feet in 1963, an annual increase of 1.9 per cent. The increase in water supply was accomplished through the development of increasingly expensive sources.

The productivity of primary resources rose substantially during the analyzed period. The annual increase in land and water productivity in the agricultural sectors is estimated at 2 to 3.5 per cent, with most sectors exceeding 3 per cent.

The growth of output and income was

marked by significant structural changes. Of particular interest are the changes in composition of output and employment. The primary agricultural sectors and the food-processing industries exhibited a rather low growth rate (.16 to 4.67 per cent annually). Of primary economic significance were the changes in the aircraft and parts industry. This sector, which in 1954 generated more than 8 per cent of the state's income (thus exceeding the state income generated in primary agriculture and food-processing sectors combined), maintained its past rate of growth through 1957; but, having passed the peak in 1957, output of the aircraft industry declined during the rest of the decade. The average rate of

TABLE 7—Continued

UC sector of origin	UC investing sector			
	29-30	31	32	37*
	<i>dollar per dollar†</i>			
1.....				
2.....				
3.....				
4.....				
5.....				
6.....				
7.....				
8.....				
9.....				
10.....				
11.....				
12.....				
13.....				
14.....				
15.....	.000260			
16.....	.009460			
17.....	.009248			
18.....	.613170			
19.....				
20.....	.025513			
21.....	.086180			
22.....	.005885			
23.....				
24.....				
25.....	.190708			
26.....				
27.....	.000494			
28.....	.000015			
29-30.....	.053905			
31.....	.000244			
32.....	.004918			
37*.....				
Total.....	1.000000			

† Dollar invested by sector source per dollar total investment.

‡ Blanks indicate zero.

change of this sector's output throughout the analyzed period was negative, —3.4 per cent annually.

The highest growth rates were experienced by the state and local governments (9.11 per cent), the fabricated metal industry (8.85 per cent), and utilities (8.74 per cent). Most other industries grew more or less at the same rate as the NSP.

Changes in employment conformed to changes in output and labor productivity.

With this general descriptive background of California's economic growth during 1954 through 1964, we shall now undertake a more detailed description

and analysis of the growth process and its determinants.

## Population

The growth of California population in the period 1953-1964 is described graphically in figure 4. The population curve is practically linear, suggesting more or less equal annual increments. As is evident from figure 5, this, in effect, was the case. The annual increase in population fluctuated over the years between 500,000 and 600,000, but the upward trend is insignificant. The annual rate of population growth, which, on the average, amounted to 3.9 per

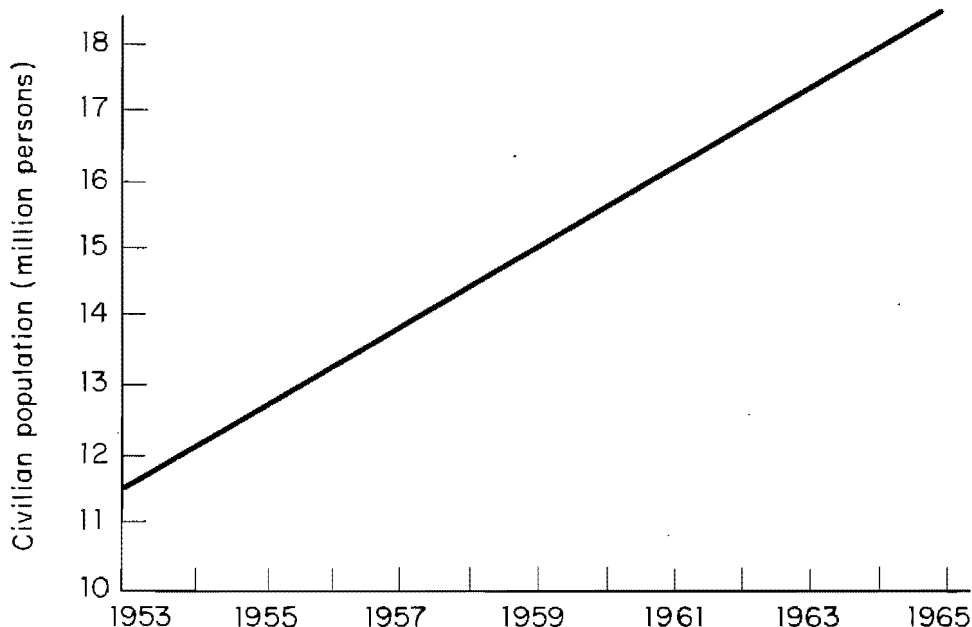


Fig. 4. California population, 1953-1965.

Source: California Interdepartmental Research Coordinating Committee (1966, p. 9).

cent, tended to fall off toward the latter years.

Most of the annual increment was due to immigration into the state which, on the average, accounted for an annual growth of 2.4 per cent. The rest was caused by the natural increase of some 1.5 per cent annually.

### Income and expenditures

Table 12 attempts to develop some principal economic indicators by applying the technical and behavioral parameters presented in the preceding section to the estimated outputs during 1954-1963. The definitions of the various indicators are essentially the same as those used in national accounts. However, the indirect method of estimation does not allow the use of the identical definitions.<sup>26</sup> Dissimilarity of definitions and estimation procedures accounts for

divergencies between the present estimates and corresponding estimates arrived at by the U. S. Office of Business Economics. During the analyzed period, NSP, state income, and private consumption grew at about the same rate, 6.1 to 6.2 per cent. However, investment grew only about half as fast, 3.2 per cent annually. The potential drop in effective demand caused by the relative decline in investment was taken up mostly by government purchase of goods and services which grew at an annual rate of 7.3 per cent and, to a much smaller extent, by some reduction in the relative importance of net imports to California. The accelerated growth of public consumption, which in effect includes investment in human capital (education) and in the state's infrastructure, thus provided the income-generating stimulus which the relatively slow-growing

<sup>26</sup> There is an important distinction between the "net" concept used in the present study, which excludes replacement flows, and the net concept ordinarily used in national accounts where depreciation charges are netted out.

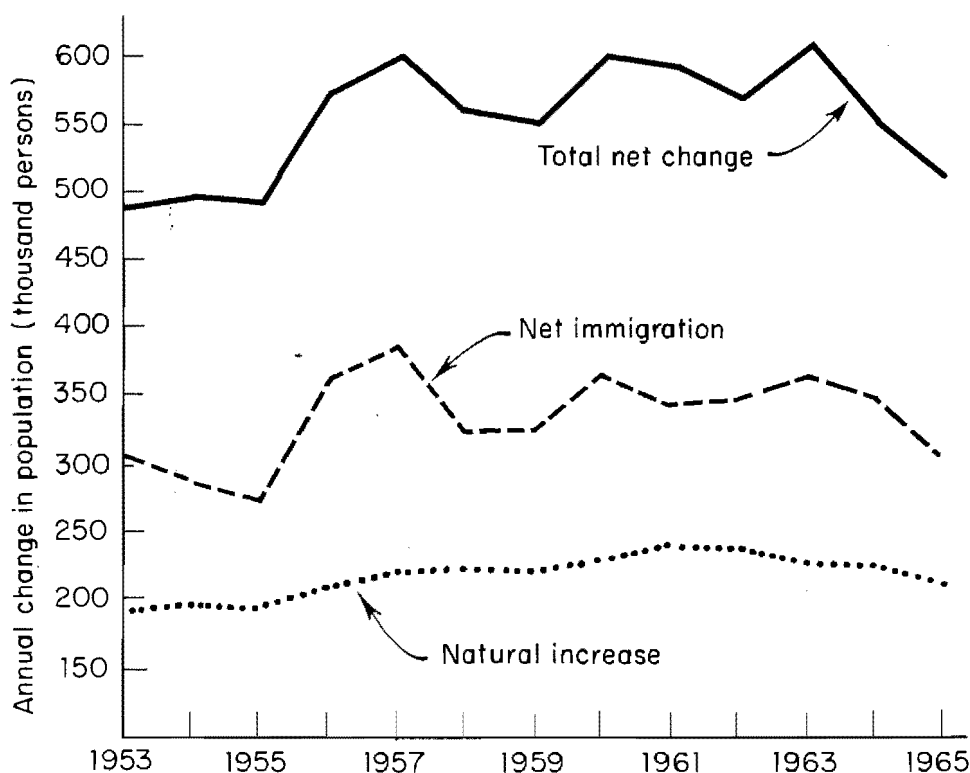


Fig. 5. Changes in California population, 1953-1965.

Source: California Interdepartmental Research Coordinating Committee (1966, p. 9).

investment failed to generate. In spite of a slow-growing investment (relative to NSP), capital accumulated at a relatively high rate because the rate of capital accumulation depends on the investment/NSP ratio. Given a capital/NSP ratio of 2.13 in 1954, the investment/NSP ratio required to support a rate of growth of 6.1 per cent in NSP at the same capital/output ratio is about

13 per cent.<sup>27</sup> In 1954 the corresponding figure was 17.2 per cent. The capital/NSP ratio was thus increasing throughout the analyzed period in spite of a relative decline in investment.<sup>28</sup> These relations are demonstrated graphically in figure 6. Except for 1958, economic growth was fairly stable. The tapering off of growth in 1958 is mostly due to the general recessive conditions prevailing

<sup>27</sup> Thus, if the capital/NSP ratio is  $b$ , capital and NSP will grow at the same rate if

$$\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{I}{bY};$$

that is, when

$$\frac{I}{Y} = b \frac{\dot{Y}}{Y}.$$

<sup>28</sup> In 1963 the investment/NSP ratio fell to 13.3 per cent, thus suggesting a stabilization of the capital/NSP ratio.

TABLE 8  
DEPRECIATION AND REPLACEMENT FLOWS, CALIFORNIA, 1954\*

UC sector of origin	UC purchasing sector										
	1	2	3	4	5	6	7	8	9	10	11
	<i>1,000 dollars</i>										
1-16.....	†										
17.....											
18.....	236	2,406	1,828	6,915	17,091	3,398	4,418	1,366	6,998	3,988	1,172 (1,087)
19.....											
20.....											
21.....	112	237	76			628	2,505			205	4
22.....											
23.....											
24.....											
25.....	147	770	536	1,893	4,670	1,594	2,385	374	1,916	1,806	303
26.....											
27.....											
28.....											
29-30.....	1,060 (667)	4,811 (3,030)	4,041 (2,544)	158 (100)	582 (356)	266 (167)	60 (38)		326 (205)	158 (100)	439 (276)
31.....		3	3	4	10	3	5	1	4	3	1
32.....	15	71	55	81	203	70	102	16	84	57	17
Total.....	1,570 (1,177)	8,298 (6,517)	6,539 (5,042)	9,051 (8,943)	22,565 (22,348)	5,959 (5,860)	9,475 (9,453)	1,757	9,328 (9,207)	5,717 (5,659)	1,936 (1,688)

TABLE 8—Continued

UC sector of origin	UC purchasing sector										
	12	13	14	15	16	17	18	19	20	21	22
	<i>1,000 dollars</i>										
1-16.....						21					
17.....						26,390					
18.....	2,198 (2,040)	3,136 (2,910)	7,863 (7,290)	15,776 (14,634)	10,450 (8,920)	33,521 (33,750)	33,521 (28,620)	76,985	17,983 (15,360)	44,658 (41,425)	8,890 (7,590)
19.....											
20.....											
21.....	54	47	21	277	877	12,374	3,291	1,092	1,026	641	66
22.....											
23.....											
24.....											
25.....	584	813	2,024	4,149	150	15,816	10,138 37	1,073	261	11,882	2,465
26.....											
27.....											
28.....											
29-30.....	1,237 (779)	992 (625)	3,841 (2,418)	5,735 (3,611)	2,005 (697)	37,088 (23,351)	12,425 (4,319)	15,139	13,410 (4,661)	20,614 (12,979)	1,886 (859)
31.....	2	2	6	11	6	47	27	43	14	34	6
32.....	36	45	121	232	131	965	549	879	296	689	119
Total.....	4,111 (3,495)	5,035 (4,442)	13,876 (11,880)	26,180 (22,914)	13,619 (10,781)	102,701 (80,324)	59,988 (46,981)	95,211	32,990 (21,618)	78,518 (67,650)	13,432 (10,902)

TABLE 8—Continued

UC sector of origin	UC purchasing sector									
	23	24	25	26	27	28	29-30	31	32	Total (offset to UC 35)
<i>1,000 dollars</i>										
1-16.....										
17.....	3									24
18.....	59,364 (50,690)	52,481 (44,810)	250,631 (214,010)	31,992 (27,320)			55,474 (47,370)			757,609 (673,455)
19.....			10,000							10,000
20.....										
21.....	4,536	24,563	8,686	26,710			2,146			90,173
22.....										
23.....										
24.....										
25.....	15,821	23,981	74,074	22,958			15,397			217,488
26.....				17,041						17,078
27.....										
28.....										
29-30.....	32,604 (11,333)	86,457 (30,052)	66,798 (23,219)	993,317 (345,277)			3,650 (1,269)			1,309,099 (487,878)
31.....	50	86	180	434			34			1,019
32.....	1,018	1,769	3,709	8,919			709			20,957
Total.....	113,396 (83,451)	189,337 (125,261)	414,078 (333,878)	1,101,371 (448,659)			77,410 (66,925)			2,423,447 (1,518,072)

\* Whenever depreciation and replacement flows are not equal, replacement flows are indicated in parentheses.

† Blanks indicate zero or approximately zero flows.

throughout the United States economy in this particular year and partly owing to the decline in the exogenous demand for the output of the aircraft manufacturing sector.

### Gross domestic output

GDO in California by UC sectoral classification and its rate of growth during 1954-1963 is given in table 13.

Worth noting is the low rate of growth of the primary agricultural sectors and the related processing industries. Thus, all crop-producing sectors [UC 4 through UC 10] grew roughly at the rate of 1-2 per cent, with citrus production actually declining. The livestock sectors fared somewhat better, with meat animals and the poultry and egg sectors growing at a rate of 4.6 to 4.8 per cent. However, the farm dairy products sector grew at the low annual rate of 1.3 per cent. Agricultural processing industries also lagged, growing at the low rates of 1.2 to 3.7 per cent annually.

Government, utilities, services, and certain nonagricultural manufacturing industries led the way, exhibiting a growth rate exceeding that of the NSP. In particular, fabricated metals and machinery, utilities, and state and local governments achieved an annual growth rate of about 9 per cent.

The decline in output of the aircraft manufacturing sector is of primary economic significance. The annual rate of decline of this industry, calculated for the entire period, was 3.1 per cent. However, because until 1958 this sector's output had actually risen, the fall of output in subsequent years was sharp. What were the determinants of output behavior during the analyzed period?

The principal output determinants may be grouped in two major categories: (1) those related to the demand conditions and (2) those having to do with developments in the factor markets and production conditions. Thus, the aircraft manufacturing sector is completely

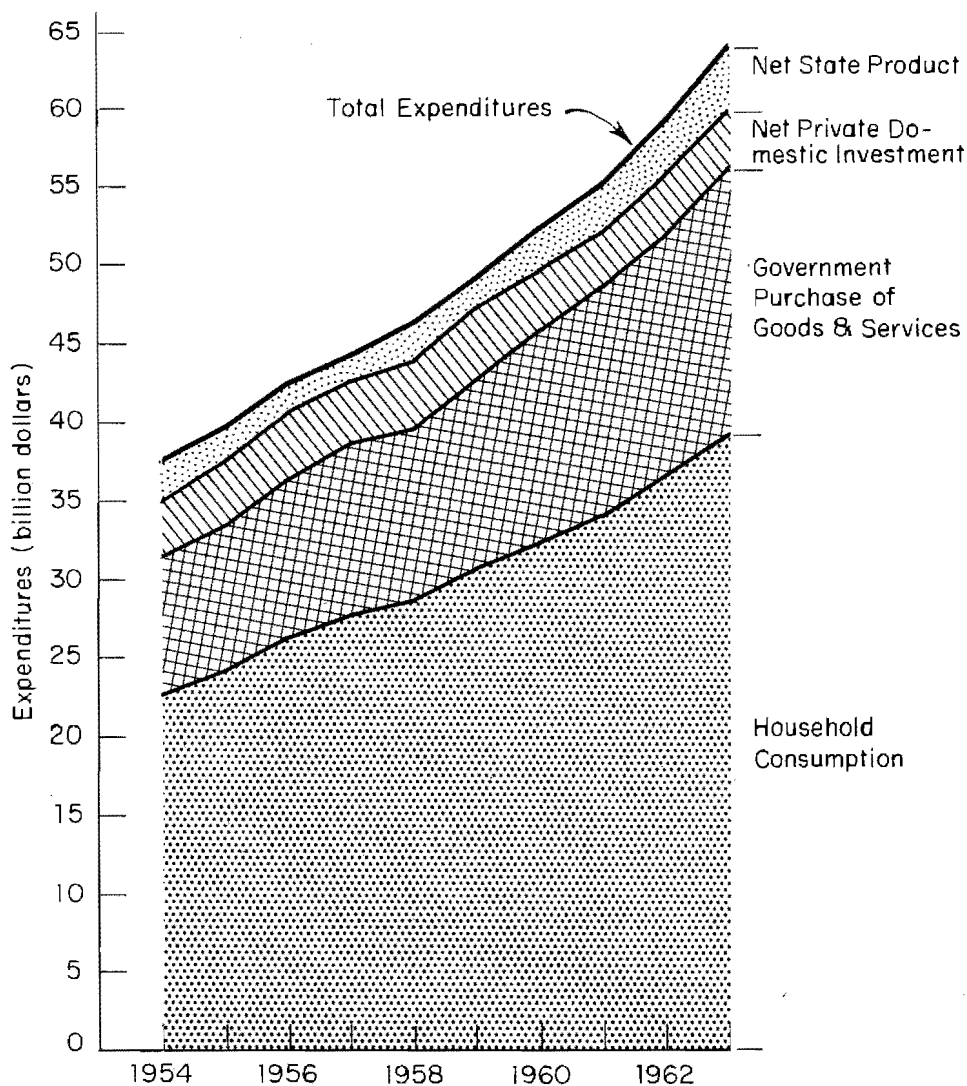


Fig. 6. State expenditures, California, 1954-1963.

demand oriented, and the evolution of its output is determined almost exclusively by exogenous demand (generated primarily by the federal government).

Likewise, outputs of public utilities and the service sectors are also demand oriented. Since these are nontradable sectors, their output is determined by intermediate and final (mostly household) domestic demand. This hypothesis

is substantiated by the close correlation between the income elasticity of demand for the sector's outputs and their rates of growth.<sup>29</sup>

Output behavior of the primary agricultural and related processing industries can be traced back to both sets of output determinants. Low-income elasticities of demand for farm products provided only a partial explanation of

<sup>29</sup> The correlation can be easily verified by comparing rates of growth given in table 13 and income elasticities of demand given in table 4.

TABLE 9  
PRIMARY RESOURCE REQUIREMENTS, CALIFORNIA, 1954

UC sector	Resource utilization				Resource coefficients			
	Labor	Total crop-land	Irrigated land	Water	Labor	Total crop-land	Irrigated land	Water
	number of employees	1,000 acres		1,000 acre-feet	employees/\$1,000 GDO	acres/\$1,000 GDO		acre-feet/\$1,000 GDO
1.....	13,980	†			.041502			
2.....	22,909				.073376			
3.....	46,478				.135291			
4.....	15,264	3,243	1,586	4,610	.077197	16.398894	8.022379	23.314184
5.....	33,293	880	880	2,392	.117094	3.094032	3.094032	8.411101
6.....	75,612	884	829	1,544	.154993	1.812918	1.609145	3.164220
7.....	79,954	1,053	805	2,618	.235407	3.109754	2.370517	7.708929
8.....	22,597	270	270	442	.164921	1.971398	1.971398	3.226082
9.....	26,021	5,829	2,303	8,458	.146915	32.166923	12.711903	46.678495
10.....	40,825	385	374	1,160	.139494	1.306946	1.270339	3.937195
11.....	7,835			4	.019408			.009977
12.....	19,065			24	.018578			.023125
13.....	20,493			17	.035913			.029276
14.....	45,507			44	.037260			.035742
15.....	59,826			52	.034639			.029916
16.....	33,700			53	.038047			.061052
17.....	52,474			81	.018848			.028370
18.....	246,954			9	.061777			.002310
19.....	250,069			4	.054965			.000956
20.....	41,395			33	.046209			.036614
21.....	348,501			135	.075593			.029293
22.....	10,053				.032841			
23.....	135,611				.085332			
24.....	394,917				.089063			
25.....	1,274,789				.156365			
26.....	750,306				.073466			
27.....								
28.....								
29-30.....	412,332				.063746			
31.....	163,000				.041126			
32.....	214,880				.039219			
37*.....	†			1,900†	.333333			
Total.....	4,859,249	12,547	7,047	23,640				

† Blanks indicate zero.

‡ Included in UC 26.

¶ Represents residential water consumption.

the sluggish growth performance of these sectors. After all, most agricultural sectors participate in trade, and their outputs may grow through import substitution or export expansion. Part of the explanation must, therefore, be attributed to developments in the factor markets and production conditions. Indeed, it would seem that the decline in the agricultural labor force, fostered by the substantial wage differentials between

farm and non-farm employment, was a major contributing factor in the slow growth of the primary agricultural sectors.<sup>30</sup> Secondary agricultural sectors were clearly affected by developments in the primary sectors. Because livestock sectors were less dependent on low-wage farm labor and because the income elasticity of demand for their outputs (both directly and indirectly through the demand for outputs of corresponding

<sup>30</sup> For more details, see pages 49-50. The decline in the output of citrus may be attributed, at least partly, to the urbanization of citrus land.



processing sectors) is somewhat higher, their growth performance was distinctly better.

Other developments are related to changes in technology which favored the capital-intensive sectors. This determinant is further explored on pages 45–49.

In industries dominated by economies of large-scale production, both external and internal, an important change in

comparative advantage generated by a technological change and factor-endowment ratio. This will be discussed later in this section.

## Capital formation

**Sources of capital formation.** Table 14 includes estimates of the sources of capital formation in the California economy during the analyzed period. Estimates of household savings were obtained by subtracting household consumption and direct taxes from the state's income. Nevertheless, "savings out of household income" figures do not represent all sources of domestic saving, because some of the value added is not distributed as household income. According to the present model, this quantity is equal to the difference between depreciation charges and actual replacement costs which, in a rapidly growing economy, may be substantial.<sup>32</sup>

Another factor worth consideration is related to our estimation procedure. Direct taxes were estimated using the the tax functions (equation 5) which failed to capture the steep upward trend in direct tax rates during the analyzed period.<sup>33</sup> Consequently, household savings in the years 1960 through 1963 were overestimated. The correction is introduced as an "estimation discrepancy" in table 14. The economic significance of the discrepancy is that rising tax rates have actually depressed household savings without generating public savings, owing to our "balanced budget" assumption. However, one should hasten to emphasize that this does not necessarily imply a negative correlation between public expenditures and growth. Indeed, a major share of public expenditures

TABLE 10  
LEVELS OF AVAILABLE PRIMARY  
RESOURCES, CALIFORNIA, 1954

Primary resource	Level
<i>Labor</i>	
Full civilian employment (1,000 employees).....	5,110
Full employment in nonagricultural sectors (1,000 employees).....	4,485
<i>Land</i>	
Total cropland in farms (acres).....	13,229,708
Irrigable land (acres).....	11,300,000
<i>Water</i>	
Supply (1,000 acre-feet).....	23,640
Potential low-cost water, UC 41 (1,000 acre-feet).....	22,200
Potential medium-cost water, UC 42 (1,000 acre-feet).....	8,600
Potential high-cost water, UC 43 (1,000 acre-feet).....	6,800

production conditions was in operation. As the domestic market expands, economies of scale become more pronounced; and the local production of a widening line of products becomes more and more profitable. This leads to progressive import substitution by domestically produced goods. Such development characterized fabricated metal and machinery [UC 18] and chemical and fertilizer [UC 16], two sectors which are known to be subject to significant economies of large-scale production.<sup>31</sup>

The output of tradable commodities also varies in response to shifts in the

<sup>31</sup> Competitive imports of UC 16 and UC 18 outputs declined substantially during the 1954–1963 period, in spite of the continuously rising demand for these products (table 18).

<sup>32</sup> Business savings in the form of undistributed profits are not considered in the present model as all profits (above depreciation charges) are regarded as household income.

<sup>33</sup> Recall that the "consumption functions"  $C_{it} = c_{i0}N_t + c_iY_t$  ( $i = 31, 32$ ) are, in fact, direct tax functions.

TABLE 11  
INPUT COEFFICIENTS OF AUXILIARY SECTORS, CALIFORNIA, 1954

UC sector	Flow-input coefficients				Investment coefficients			
	$a_{i,41}$	$a_{i,42}$	$a_{i,43}$	$a_{i,51}$	$w_{i,41}$	$w_{i,42}$	$w_{i,43}$	$w_{i,51}$
	\$1,000/acre-foot			\$1,000/ acre	dollar per dollar†			
1.....	‡							
2.....								
3.....								
4.....								
5.....								
6.....								
7.....								
8.....								
9.....								
10.....								
11.....								
12.....								
13.....								
14.....								
15.....								
16.....								
17.....	.000019	.000110	.000400					
18.....	.000486	.000220		.002233				.580497
19.....								
20.....								
21.....	.000142	.000140	.000200					
22.....								
23.....	.002068¶	.002210	.008900					
24.....	.000342	.000440	.000700					
25.....	.000053			.000611				.120976
26.....	.000106	.000270	.000500					
27.....								
28.....								
29-30.....	.001110	.005150	.010000	.001107	1.000000	1.000000	1.000000	.285580
31.....	.000076	.000020		.000002				.000324
32.....				.000032				.006623
37*.....								
Total.....	.004402	.008560	.020700	.003985	1.000000	1.000000	1.000000	1.000000
Household income.....	¶	.014150	.037410					
Total capital§.....					.032670	.360000	.900000	.101516
Labor  .....	.000124	.000402	.000705					

† Dollar invested by sector source per dollar total investment.

‡ Blanks indicate zero.

¶ Household income of UC 41 is included in UC 23.

§ \$1,000 per unit output.

|| Employees per unit output.

consists of investment in infrastructure and human capital, without which the observed technological progress (reflecting better technique as well as an improved infrastructure) might not be realized. Unfortunately, this effect cannot be captured by the present model.

The annual rate of investment was calculated by applying the capital coefficients to the observed changes in output. It is obvious from table 14 that the observed growth in output could not be

fully supported by domestically generated savings, which provided only about two-thirds of the required capital resources. This assertion will be further substantiated when maximal growth paths for the California economy are considered.

Two types of imported capital funds are conceivable: (1) loans and (2) unilateral capital transfers. The latter type is of particular interest in the case of California since the considerable immi-

TABLE 12  
CALIFORNIA SOCIAL ACCOUNTS, 1954-1963

	1954*	1955	1956	1957	1958	1959	1960	1961	1962	1963	Annual growth rate
	<i>million dollars (1954 prices)</i>										<i>per cent</i>
<i>Income</i>											
1. Domestic state income.....	30,220	32,490	35,270	37,042	38,050	40,901	42,921	45,201	48,267	51,814	6.2
2. Interest received on foreign investment.....	0	— 43	— 43	10	82	72	109	116	100	64	
3. State income (1 + 2).....	30,220	32,447	35,227	37,053	38,132	40,973	43,030	45,318	48,368	51,878	6.2
4. Depreciation minus replacement plus indirect business taxes.....	4,603	5,023	5,333	5,543	5,750	6,214	6,431	6,763	7,166	7,622	5.7
5. Net state product (3 + 4).....	34,823	37,470	40,560	42,596	43,882	47,187	49,461	52,081	55,534	59,500	6.1
<i>Expenditures</i>											
1. Household consumption.....	22,498	24,169	26,252	27,624	28,442	30,570	32,131	33,871	36,178	38,827	6.2
2. Net private domestic investment.....	6,002	6,230	6,067	5,625	6,530	6,574	6,407	6,569	7,197	7,943	3.2
3. Government purchase of goods and services.....	8,927	9,133	10,057	10,939	11,192	11,874	13,432	14,422	15,482	16,881	7.3
4. Net exports.....	— 2,317	— 1,785	— 1,505	— 1,258	— 1,947	— 1,489	— 2,114	— 2,360	— 2,873	— 3,664	5.3
5. Federal surplus.....	— 287	— 277	— 311	— 334	— 335	— 342	— 395	— 421	— 450	— 487	
6. Net state product (1 + 2 + 3 + 4 + 5).....	34,823	37,470	40,560	42,596	43,882	47,187	49,461	52,081	55,534	59,500	

\* Figures were computed using input-output coefficients and are, therefore, not identical with figures in table 1.

SOURCE: The table entries were obtained by applying the input-output coefficients to estimated outputs as explained in Appendix B, California Income and Expenditures.

TABLE 13  
GROSS DOMESTIC OUTPUTS BY UC SECTORS, CALIFORNIA, 1954-1963

UC sector	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Annual growth rate
	<i>million dollars (1954 prices)</i>										<i>per cent</i>
1. Meat animals and products.....	339	332	368	324	348	372	425	452	498	505	4.8
2. Poultry and eggs.....	312	354	338	341	356	385	416	465	487	467	4.6
3. Farm dairy products.....	344	356	362	381	380	399	408	416	420	418	1.3
4. Food and feed grains.....	193	200	201	217	204	223	220	216	233	216	1.3
5. Cotton.....	284	230	274	292	305	367	370	322	364	326	2.5
6. Vegetables.....	492	561	652	580	619	587	602	613	664	630	2.8
7. Fruits and nuts (excluding citrus).....	336	376	391	344	348	401	384	382	398	383	1.6
8. Citrus.....	137	146	141	142	111	156	132	108	101	114	-2.0
9. Forage.....	181	186	190	194	195	196	199	204	195	212	1.8
10. Miscellaneous agriculture.....	295	279	307	280	285	288	268	282	310	314	.6
11. Grain mill products.....	404	410	420	430	445	462	488	512	538	560	3.7
12. Meat and poultry processing.....	1,026	1,040	1,060	1,090	1,109	1,125	1,140	1,155	1,170	1,195	1.7
13. Dairy products.....	571	587	618	643	662	680	695	705	720	734	2.8
14. Canning, preserving, and freezing.....	1,188	1,257	1,358	1,283	1,255	1,280	1,291	1,280	1,310	1,319	1.2
15. Miscellaneous agricultural processing.....	1,727	1,800	1,850	1,900	1,970	2,020	2,080	2,140	2,200	2,279	3.1
16. Chemicals and fertilizers.....	865	1,040	1,160	1,280	1,418	1,494	1,551	1,593	1,654	1,689	7.7
17. Petroleum.....	2,861	2,925	3,000	3,075	3,148	3,275	3,425	3,600	3,775	4,020	3.9
18. Fabricated metals and machinery.....	3,998	4,400	4,950	5,590	6,338	6,750	7,180	7,650	8,200	8,857	9.3
19. Aircraft and parts.....	4,460	4,513	5,057	5,375	4,548	4,485	3,827	3,503	3,397	3,377	-3.1
20. Primary metals.....	896	1,060	1,214	1,285	1,175	1,290	1,366	1,415	1,490	1,517	6.0
21. Other manufacturing.....	4,645	5,010	5,170	5,126	5,019	5,365	5,404	5,327	5,478	5,607	1.3
22. Mining.....	324	375	446	421	408	462	467	493	506	550	6.0
23. Utilities.....	1,589	1,801	1,896	2,009	2,200	2,450	2,725	2,974	3,188	3,404	8.9
24. Selected services.....	4,493	4,758	5,059	5,463	5,741	6,238	6,566	6,893	7,284	7,734	6.2
25. Trade and transportation.....	8,153	8,920	9,441	9,807	10,179	10,750	11,230	11,050	12,740	13,650	5.9
26. Unallocated services.....	10,113	11,055	11,710	12,165	12,026	13,834	14,485	15,451	16,546	17,798	6.5
27. Scrap and by-products.....	229	250	265	275	285	313	328	349	374	402	6.5
28. Noncompetitive imports*	835	858	936	963	970	1,014	1,101	1,153	1,222	1,286	5.0
29-30. Construction.....	6,468	7,289	8,067	7,869	8,048	8,879	8,708	8,917	9,560	10,482	5.5
31. State and local government.....	3,063	4,304	4,695	5,182	5,420	5,994	6,636	7,186	7,756	8,527	8.9
32. Federal government.....	5,479	5,285	5,935	6,377	6,392	6,540	7,547	8,040	8,588	9,291	6.0

\* Including federal surplus. Computed from other sector outputs using input-output coefficients.

TABLE 14  
CAPITAL FORMATION, CALIFORNIA, 1954-1963\*

Sources and uses	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
	million dollars (1954 prices)									
<i>Sources</i>										
Savings out of household income.....	2,931	3,124	3,378	3,479	3,646	3,905	4,074	4,254	4,502	4,794
Depreciation minus replacement plus estimation discrepancy.....	467	1,043	871	553	784	836	— 178	— 209	— 628	—1,002
Unilateral capital transfer.....	1,913	2,070	2,673	2,729	2,126	2,417	2,628	2,524	2,749	3,022
All sources.....	5,311	6,237	6,922	6,761	6,374	7,158	6,524	6,311	6,623	6,814
<i>Uses</i>										
Net private domestic investment.....	6,002	6,280	6,067	5,625	6,530	6,574	6,407	6,569	7,197	7,943
Net foreign investment.....	— 691	7	855	1,138	— 156	584	117	— 258	— 574	—1,129
Total net investment.....	5,311	6,237	6,922	6,761	6,374	7,158	6,524	6,311	6,623	6,814

\* Estimated.

SOURCE: For calculation and sources, see Appendix B, California Capital Formation, 1954-1963 Sources.

gration into the state was bound to involve substantial unilateral transfers.

Because no data permitting direct estimation of transfer rates were available, some rough estimates were obtained on the assumption that the wealth position of a representative immigrant equaled that of an average American. Per-capita property ownership in the United States was derived by capitalizing property income reported by the U. S. Office of Business Economics (see Appendix B, page 108). Admittedly, our estimates are based on rather strong assumptions. Yet, this is no doubt preferable to ignoring the transfer phenomena altogether. Remarkably enough, total estimated capital transfer during the entire period was about equal to the capital funds required to complement domestic savings. This is by no means a validation of the estimation procedure. The accumulated value of net savings and unilateral transfers during the years 1954-1963 is \$65,035,000,000, and total equity capital at the end of 1963 amounted to \$139,179,000,000—a rate of growth of 6.5 per cent annually.

**Uses of investment resources.** The high rate of growth of domestic production required high rates of expansion in domestic productive capacities. Consequently, all investment resources were diverted to domestic investment. This applied to the period as a whole, with annual net foreign investments fluctuating at about zero in individual years.

### Civilian labor force and employment

California's civilian labor force grew during the analyzed period at the annual rate of about 3.3 per cent from 5,110,000 workers in 1954 to 6,860,000 workers in 1963. This rate of growth is somewhat lower than the rate of increase in population, thus signifying a slight decline in the labor force participation rate.

Annual employment figures are presented in table 15 and are described graphically in figure 7. Actual employment grew at the rate of 3.2 per cent and, since the NSP grew at an annual rate of 6.1 per cent, average labor productivity rose at the annual rate of 2.9 per cent. The change in productivity is

TABLE 15  
CIVILIAN LABOR FORCE AND EMPLOYMENT, CALIFORNIA, 1954-1963

Labor force and employment	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
	<i>1,000 employees</i>									
Total civilian labor force.....	5,110	5,308	5,566	5,797	5,904	6,104	6,299	6,481	6,651	6,860
Civilian employment.....	4,856	5,045	5,378	5,554	5,526	5,812	5,933	6,036	6,262	6,449
Agricultural employment.....	378	385	382	375	367	366	354	350	345	340
Nonagricultural employment.....	4,478	4,710	4,996	5,179	5,159	5,446	5,579	5,686	5,916	6,109
	<i>per cent</i>									
<i>United States</i>										
Unemployment rate.....	5.5	4.4	4.1	4.3	6.8	5.5	5.5	6.7	5.5	5.7
<i>California</i>										
Unemployment rate.....	5.0	3.9	3.4	4.2	6.4	4.8	5.8	6.9	5.8	6.0
Share of agricultural employment in total civilian employment.....	7.8	7.6	7.1	6.8	6.6	6.3	6.0	5.8	5.5	5.3

## SOURCES:

U. S. Office of Business Economics, 1965.

California Interdepartmental Research Coordinating Committee, 1966.

attributable primarily to the labor-augmenting technological change. (See discussion on pages 43-45).

Beginning in 1958, unemployment rates markedly increased. This development followed the general United States pattern. Considering the substantial cut-back in output of the aircraft sector—about \$800 million from 1957 to 1958 alone—California's economy must have faced a severe adjustment problem.

Changes in composition of civilian employment are of particular interest. Despite a rapidly growing labor force and total employment, agricultural employment was, in effect, declining. Consequently, the share of agricultural employment dropped from 7.8 per cent in 1954 to 5.3 per cent in 1963. The movement of labor out of agriculture, to a large extent, can be explained by the prevailing wage differentials. Wages per hired employee in agriculture in 1954 were estimated to be \$1,656 annually as compared to \$3,423-\$5,559 annually in manufacturing industries (Martin and Carter, 1962, table 5.43). Labor migration also included owner-operators who found outside of agriculture more remunerat-

ing employment opportunities for their managerial ability, accumulated capital, and labor services.

### Land and water resources

The extent to which development in land and water resources was responsible for the observed growth in agricultural production is partly shown in table 16.

Evidently, whatever increase in agricultural production took place, occurred in spite of a decline of about 1 per cent annually in total cropland, from 13,230,000 acres in 1954 to 12,046,000 acres in 1963. Because production of crops grew at the rate of about 2 per cent a year, average land productivity must have risen at about 3 per cent annually (table 13). This was achieved chiefly through technological progress but partly through a shift toward more intensive crops (mostly vegetables and cotton).

Water supply, on the other hand, kept growing, although at the rather low annual rate of 1.9 per cent. Annual water deliveries grew from 23,640,000 acre-feet in 1954 to 27,870,000 in 1962—a rise of 4,230,000 acre-feet, of which

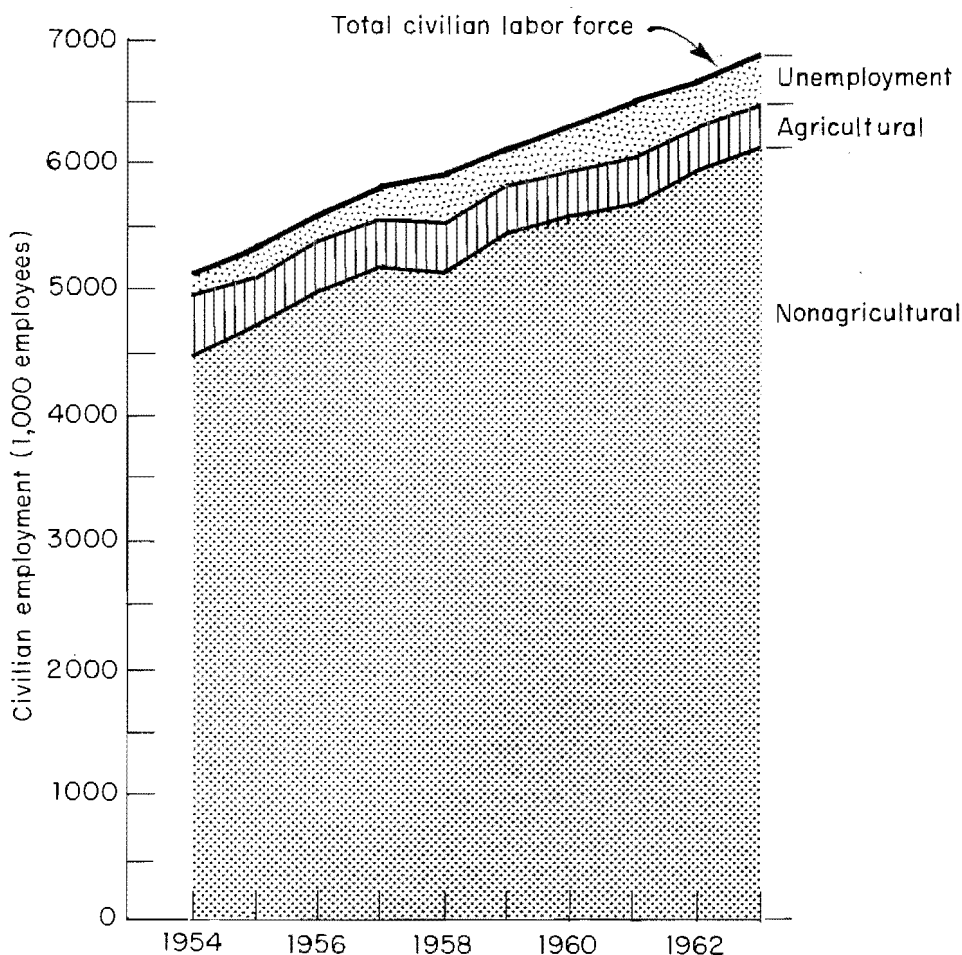


Fig. 7. Civilian employment by major sectors, California, 1954-1963.

1,405,000 acre-feet were taken up by increased residential and other non-manufacturing and nonfarm uses; 175,000 acre-feet were used to meet increased water demand by manufacturing industries, and 2,650,000 acre-feet were diverted to agricultural sectors. This represents an annual increase of about 1.3 per cent in water utilization by primary agriculture. The increase of agricultural output in face of a small additional water supply was made possible mostly by the water-augmenting technological change.

By 1954 all potential low-cost water had already been developed, and

throughout 1954-1963 only medium-cost water sources were developed. Toward the end of the period, these, too, were almost fully tapped.

### Technological progress

As indicated, technological change was incorporated into the model by lowering the values of the coefficients in *A* and *R*. That is, a flow input and primary resource-augmenting technological change was assumed.

**Changes in the productivity of flow inputs.** The state income during the analyzed period was estimated initially by applying equation (4) and the 1954

TABLE 16  
HARVESTED CROPLAND, IRRIGATED LAND, AND WATER SUPPLY,  
CALIFORNIA, 1954-1963

Resource	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Total cropland (1,000 acres).....	13,230	13,177	13,124	13,071	13,018	12,966	12,736	12,506	22,276	12,046
Irrigated land (1,000 acres).....	7,048	7,118	7,187	7,257	7,326	7,396	7,436	7,477	7,517	7,558
Water supply (1,000 acre-feet)										
Low cost (UC 41).....	22,200	22,200	22,200	22,200	22,200	22,200	22,200	22,200	22,200	22,200
Medium cost (UC 42).....	1,440	1,910	2,380	2,850	3,320	3,790	4,260	4,730	5,200	5,670
High cost (UC 43).....	*									
Total water.....	23,640	24,110	24,580	25,050	25,520	25,990	26,460	26,930	27,400	27,870

\* Blanks indicate zero.

SOURCES:

U. S. Bureau of the Census, 1967; Hoch and Phillips, 1970; Zusman and Hoch, 1965.

coefficients to observed outputs. The resulting income series implied an annual rate of growth of 5.5 per cent as compared to 6.5 per cent annual growth rate of California personal income reported by the U. S. Office of Business Economics (1966). This suggested an annual increase of  $\epsilon = .01$  in the income coefficients,  $u_j$ , and a corresponding reduction in the values of  $a_{ij}$ . The technological change was assumed to take place in UC 1 through UC 26 and UC 29-30. Accordingly, income coefficients of these sectors were uniformly raised by 1 per cent annually.<sup>34</sup> The uniformity assumption was adopted for lack of detailed relevant information.

**Changes in labor and resource productivity.** In contrast to flow-input technological progress, it was possible to develop specific rates of technological progress by factor and sector break-

down. It was assumed that labor productivity varies at different rates depending on the sector in which it is employed. Likewise, land and water productivity changes also depend on the using sector, while being equal for both types of natural resources. Specific annual rates of change in the resource requirement coefficients are listed in table 17.

Changes in labor productivity in the agricultural sector were not uniform. While some sectors, such as field crops and cotton, exhibited a very high rate of labor-saving improvements, other sectors, such as the fruit sectors, did not advance at all. On the average, labor productivity in the agricultural sectors rose at the rate of 3 per cent annually. In the manufacturing sectors, a more uniform behavior is observed.<sup>35</sup> On the average, labor productivity in manu-

<sup>34</sup> The adjustment of the coefficients  $a_{ij}$  and  $u_j$  was performed according to the following formulae:

$$a_{ij}^{t+1} = a_{ij}^t g_j^t$$

where

$$g_j^t = \frac{1 - (1 - \sum_i a_{ij}^t)(1 + \epsilon)}{\sum_i a_{ij}^t}.$$

$$u_j^{t+1} = u_j^t(1 + \epsilon)$$

where  $t$  indexes the year, and  $\epsilon$  equals .01.



TABLE 17  
ANNUAL RATES OF CHANGE IN  
LABOR, LAND, AND WATER  
REQUIREMENT COEFFICIENTS,  
CALIFORNIA, 1954-1963

UC sector of use	Labor	Land	Water
1.....	-.007839	†	
2.....	-.074417		
3.....	-.041595		
4.....	-.071582	-.037629	-.037629
5.....	-.002002	-.031750	-.031750
6.....	-.028655	-.022865	-.022865
7.....		-.014973	-.014973
8.....		-.019801	-.019801
9.....	-.030182	-.033350	-.033350
10.....	-.035959	-.028750	-.028750
11.....	-.033817		
12.....	-.033817		
13.....	-.033817		
14.....	-.033817		
15.....	-.033817		
16.....	-.033256		
17.....	-.024866		
18.....	-.035680		
19.....	-.035680		
20.....	-.035029		
21.....	-.024581		
22.....	-.029780		
23.....	-.055892		
24.....	-.030068		
25.....	-.023724		
26.....	-.019995		
27.....			
28.....			
29-30.....	-.025057		
31.....	-.003687		
32.....	-.003687		
37*			
State average†	-.025374	-.031626	-.027416

† Blanks indicate zero or the factor is not used in the respective sector.

‡ Average weighted by the amounts of the factor used.

facturing rose at a rate of 3.1 per cent.

Most other sectors of the economy enjoyed much smaller productivity gains. In particular, the trade, services, and government sectors lagged behind. Because employment in the laggard sectors constitutes a major share of total employment, labor productivity in the economy as a whole advances at the annual rate of 2.5 per cent only.

All productivity measures cited above are in terms of labor requirement per

unit of GDO. However, technological progress in the flow input-output relations implies an even higher rate of increase in labor productivity in terms of the income generated. Because the domestic state income rose at the rate of 6.2 per cent and employment at the rate of 3.2 per cent, income generated per employee rose at the rate of 3 per cent annually. On the other hand, the average increase in productivity (in terms of GDO) was 2.5 per cent which, together with the increase in the productivity of flow inputs, amounts to an annual rate of increase in labor productivity in terms of income of about 3.5 per cent. The difference in the two measures of productivity change reflects changes in the composition of employment in the direction of more labor-intensive sectors.

Changes in land and water productivity reflect the rise in yields. Again, the fruit sectors are laggards, mostly because the perennial nature of orchards does not allow rapid adoption of new technologies, particularly new varieties.

Land and water productivity changes in any given sector were equal by assumption, but average productivity gains differ because of the difference in the weighting systems.

## California's pattern of trade and balance of payments

**The pattern of trade.** Quantities traded in each year of the analyzed period were estimated by applying the model (see pages 5 ff.) to the observed outputs. The values of the trade variables were obtained as residuals after subtracting the calculated intermediate demand, household demand, and investment demand from observed outputs.

<sup>35</sup> The uniformity of technological progress in the manufacturing sector is, in part, an artifact created by the estimation procedure. Thus, all agricultural processing sectors are assumed to involve the same rate of change since the information used in estimation did not allow further differentiation. For more detail, see Appendix B, Technological Progress.

TABLE 18  
CALIFORNIA TRADE, 1954-1963

UC trading sector	1954†	1955	1956	1957	1958	1959	1960	1961	1962	1963
million dollars (1954 prices)										
1.....	- 232‡	- 274	- 217	- 275	- 265	- 296	- 223	- 222	- 146	- 142
2.....	- 9	22	- 5	- 14	- 16	- 7	3	36	43	8
3.....	- 9	- 2	- 26	- 4	- 31	- 19	- 18	- 17	- 20	- 41
4.....	- 1	- 4	- 11	9	- 13	- 2	- 18	- 37	- 30	- 57
5.....	245	188	226	240	226	313	315	264	301	259
6.....	129	189	258	187	221	176	178	181	217	170
7.....	49	75	72	36	41	88	66	63	71	83
8.....	108	116	109	109	79	122	97	72	64	76
9.....	- 6	- 2	- 8	5	0	- 10	- 22	- 26	- 46	- 30
10.....	40	18	38	16	14	12	- 9	6	24	12
11.....	- 49	- 67	- 62	- 62	- 67	- 72	- 73	- 80	- 74	- 55
12.....	- 209	- 262	- 320	- 356	- 391	- 457	- 514	- 572	- 646	- 716
13.....	- 105	- 116	- 119	- 128	- 140	- 155	- 175	- 198	- 218	- 242
14.....	334	842	940	847	803	807	798	768	776	756
15.....	- 222	- 224	- 265	- 297	- 309	- 352	- 389	- 418	- 463	- 487
16.....	- 559	- 499	- 479	- 421	- 352	- 366	- 351	- 361	- 384	- 441
17.....	559	490	436	437	448	401	430	459	437	445
18.....	-3,028	-2,784	-2,405	-2,044	-1,857	-1,628	-1,514	-1,423	-1,492	-1,446
19.....	4,094	4,028	4,543	4,860	4,108	4,054	3,452	3,157	3,060	3,042
20.....	-1,016	-1,018	-1,062	-1,120	-1,247	-1,278	-1,222	-1,236	-1,243	-1,415
21.....	-2,648	-2,691	-2,926	-3,135	-3,507	-3,569	-3,794	-4,172	-4,531	-4,964
22.....	145	196	260	235	220	260	264	286	287	318
23.....	- 151	- 73	- 93	- 56	82	176	344	465	530	576
24.....	530	548	488	673	823	937	1,011	1,058	1,047	1,025
25.....	- 121	178	111	112	117	94	121	324	369	445
26.....	165	258	16	- 137	- 32	227	123	288	345	366
27.....	- 15	- 21	- 25	- 23	- 14	- 4	- 2	11	22	43
28.....	- 835	- 858	- 936	- 963	- 970	-1,014	-1,101	-1,153	-1,222	-1,286
29-30.....	¶									
31.....										
32.....										
37*.....										
Net exports.....	-2,317	-1,741	-1,462	-1,260	-2,029	-1,563	-2,223	-2,477	-2,973	-3,728

† 1954 exports and imports were computed separately and are, therefore, not identical with figures in table 1.

‡ Negative entries signify imports; positive entries, exports.

¶ Blanks indicate zero.

The resulting estimates are given in table 18.

Being residual estimates, the figures tend to exhibit strong annual fluctuations and to involve accumulated estimational errors, so that only general trends are economically meaningful.

In examining table 18, the following trends in the pattern of trade are evident:

(a) *Primary agriculture.* Trade in livestock products tended to be stable. At the same time, the imports of grains and forage increased, indicating a growing reliance of California's livestock production on imported feed. Exports of vegetables tended to rise at the beginning of the period but dropped off again after

1956. Exports of fresh citrus fruits declined throughout the period.

Developments in the livestock, grain, and feed sectors can be explained by a rising domestic demand for livestock products in the face of diminishing land supply and a rather small increase in water supply. Indeed, one wonders why imports of livestock products did not rise substantially. We shall presently see that the pressure of rising demand showed up in increased imports of processed livestock products.

The decline in citrus exports appears to result from the rapid urbanization of citrus land.

(b) *Manufacturing.* The slow growth

in primary agricultural production, relative to the rise in demand for agricultural products, was reflected in the development of trade in processed agricultural products. Imports of processed meat and poultry products [UC 12] rose substantially. A similar development, though less pronounced, took place in dairy products and miscellaneous processed agricultural goods.

Developments in exports by the canning, preserving, and freezing sector were consistent with the general trend. After a short rise at the beginning of the period, exports tended to fall off in subsequent years.

Imports of fabricated metals and machinery [UC 18], during the analyzed period declined by more than 50 per cent despite the growing demand for these goods generated by continuously expanding investment activities. This development in trade can be ascribed to three major factors whose specific importance is difficult to assess. First, it is possible that the drop in the exogenous demand for aircraft and parts released resources which were diverted to the production of fabricated metals and machinery. Second, as domestic demand for these goods expands, the comparative advantage of domestic production vis-a-vis imports is enhanced. This is because economies of large-scale production, both internal and external, are of primary importance in the production of fabricated metals and machinery. Economies of large-scale production might also account for the decline in imports of chemicals and fertilizers [UC 16]. Third, technological progress continuously shifted the comparative advantage in favor of the capital-intensive goods. Both the fabricated metal and the chemical industry benefited from this change.

Developments in an opposite direction are evident in the importation of primary metals [UC 20] and other

manufacturing [UC 21]. Production of primary metals is resource oriented, and one expects heavy reliance on imports, especially when the production of fabricated metals expands rapidly. This, however, is not the case with other manufacturing. Evidently, growth of other sectors bids away resources from UC 21 whose comparative advantage was declining. Table 17 shows that labor productivity in other manufacturing [UC 21] advanced at the rate of 2.5 per cent annually, as compared to an annual rate of change of 3.1 per cent in all manufacturing sectors. The differential rate of technological progress thus reinforced the general trend toward production of more capital-intensive goods.

(c) *Other sectors.* Of great significance is the observed increase in the export of services, especially in the selected services sector which consists of hotels, motels, general recreational services, personal and business services, and various amusement services. These are invisible exports closely associated with tourism.

**California's balance of payments.** The economic developments during the analyzed period are reflected in the annual balance of payments given in table 19. The high rate of economic growth was accompanied by an investment rate in excess of domestic saving, thus creating a perennial deficit in the current account. However, unilateral capital transfers by immigrants, on the whole, offset the deficit and in some years even led to net investment outside the state.

Although the terminology adopted in the present study is identical with that used for independent countries, its economic significance may be quite different. Thus, given the highly developed United States capital market and the use of a uniform monetary unit, the problem of the "international liquidity" position of the California economy is practically meaningless. This problem is of utmost

TABLE 19  
BALANCE OF PAYMENTS, CALIFORNIA, 1954-1963

Variable	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
<i>million dollars (1954 prices)</i>										
<i>Current account</i>										
Net export of goods and services*	-2,317	-1,741	-1,462	-1,269	-2,029	-1,562	-2,223	-2,477	-2,973	-3,728
Interest receipts on foreign investment	0	-43	-43	10	82	72	109	116	100	64
Federal surplus	-287	-277	-311	-334	-335	-342	-395	-421	-450	-487
Total current account	-2,604	-2,061	-1,816	-1,593	-2,282	-1,832	-2,509	-2,782	-3,323	-4,151
<i>Capital account</i>										
Unilateral transfers	1,913	2,070	2,673	2,729	2,126	2,417	2,628	2,524	2,749	3,022
Net borrowing	691	9	857	-1,136	156	-585	-119	258	574	1,129
Total capital account	2,604	2,061	1,816	1,593	2,282	1,832	2,509	2,788	3,323	4,151
Accumulated foreign investment†	-691	-682	175	1,311	1,155	1,740	1,859	1,601	1,027	-102

\* Exclusive of capital services.

† Calculated at the end of the year on the assumption that at the end of 1953 accumulated foreign investment equaled zero.

importance for independent countries.

We employed the theory advanced on page 11 to explain the observed economic trends during the decade 1954-1963. Our theory pretended to explain secular behavior alone, abstracting from short-run phenomena.

The main factors inducing change in the pattern of trade and capital movement which operated during the analyzed period, are summarized in table 20.

The table suggests that (1), flow inputs augmenting technological change encouraged production in the capital-intensive sectors without any compensating effects by the other factors; (2), while technological progress and developments in demand for nontradable commodities and exogenous exports strengthened the propensity to borrow, this tendency was counteracted by the rapid increase in the capital/labor ratio in the economy.<sup>36</sup>

To what extent was the actual evolu-

tion of the pattern of trade and capital movement consistent with the foregoing predictions?

The analysis of trade in primary and processed agricultural commodities is confounded by the effects of water and land resources.<sup>37</sup> Other manufacturing sectors offer a somewhat clearer case. Examining the relations between the sector's capital/labor ratios and changes in trade, we find the following:

UC sector	Capital/labor ratio	Observed changes in trade
UC 16	11.645	Imports decreasing
UC 18	9.638	Imports decreasing rapidly
UC 20	16.890	Imports increasing
UC 21	6.851	Imports increasing rapidly

With the exception of UC 20, the relations cited above tend to substantiate the theoretical prediction. Since the primary metal industry [UC 20] has a strong locational orientation toward certain

<sup>36</sup> The most capital-intensive sectors producing nontradable goods and exogenous exports are (in the order of capital intensity) UC 26, UC 23, and UC 25. These sectors grew at the annual rate of 6.5, 8.9, and 5.9 per cent, respectively. When the size of the sectors is considered, it is evident that much of the accumulated capital was diverted to sectors producing nontradable goods. The positive correlation between capital intensity and income elasticity of demand is of great economic significance. Is it possible that the celebrated "Leontief paradox" (Leontief, 1953 and 1956) is, at least partly, due to this correlation?

<sup>37</sup> Here "land" is understood to include California's particular climatic conditions.

TABLE 20  
SUMMARY OF OPERATING FACTORS INDUCING CHANGE IN THE PATTERN  
OF TRADE AND CAPITAL MOVEMENT, 1954-1963

Operating factor	Annual rate of change	Hypothesized effect on pattern of trade	Hypothesized effect on capital movement
1. Flow inputs augmenting technological change (annual change in flow coefficient)	-.01	Encourages capital-intensive sectors	Encourages borrowing
2. Labor-augmenting technological change (annual change in labor coefficient)	-.025	No effect	Encourages borrowing
3. Change in the capital/labor ratio in the economy	.033	No effect	Encourages lending
4. Relative rates of growth of nontradables and exogenous exports	Capital-intensive sectors grow faster	No effect	Encourages borrowing

mining resources and localities which have historically specialized in the production of these goods, its deviation does not repudiate our hypothesis. However, the situation is ambiguous because economies of large-scale production and a rapidly expanding market combined with declining production in the aircraft sector could have produced the same observed behavior. It is, therefore, suggested that both economic mechanisms were in operation during the analyzed period.

Borrowing and lending fluctuated throughout the period. These were short-run phenomena. However, to the extent that 10 years are sufficient to establish a long-run trend, developments suggest a tendency to zero net borrowing—that is, the operating forces in effect canceled out each other.<sup>38</sup>

### The role of agriculture in the growth process

Contrary to a widely held opinion, agriculture was not a major sector of the California economy during the analyzed period. Thus, income generated in primary agricultural sectors in 1954

amounted to \$1,493,000,000—about 4.9 per cent of the state's income in that year. If we add the agricultural-processing sectors, income rises to \$2,476,000,000, which constitutes about 8.2 per cent of the state's income. Hence, developments in the agricultural sectors could not affect profoundly the overall economic development.

The contribution of the agricultural sectors may be analyzed in relation to three main aspects: (1) output and income contribution, (2) factor contribution, and (3) trade contribution. The relevant figures are given in table 21.

Table 21 substantiates the assertion concerning the limited importance of primary agriculture. In fact, income, resources, and trade contributions to growth are relatively minor. The remarkable fact, however, is the continuous rise in agricultural output despite the outflow of resources. The sixth row in the table suggests that the rate of growth of agriculture was lower than that which savings generated within this sector are capable of supporting—the excess savings being transferred to other sectors

<sup>38</sup> In the second half of the analyzed period, interest rates increased in the United States (U. S. Office of Business Economics, 1965). This might have also slowed down the shift to capital-intensive sectors and lowered the rate of borrowing.

TABLE 21

## THE CONTRIBUTION OF PRIMARY AGRICULTURAL SECTORS TO ECONOMIC GROWTH, CALIFORNIA, 1954-1963

Variable	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
<i>million dollars (1954 prices)</i>										
Agricultural output.....	2,013	3,020	3,224	3,085	3,151	3,374	3,424	3,460	3,670	3,585
Net value added in agriculture.....	1,497	1,583	1,711	1,653	1,691	1,824	1,832	1,829	1,961	1,926
Income generated in agriculture.....	1,403	1,559	1,700	1,648	1,686	1,819	1,826	1,823	1,954	1,920
Net saving in agriculture.....	150	157	172	166	170	183	184	185	198	194
Net investment in agriculture.....	159	118	59	21	176	100	79	91	20	153
Saving transferred from agriculture to nonagricultural sectors.....	— 8	39	113	145	— 6	83	105	94	178	41
Net agricultural exports.....	314	326	436	309	250	377	369	320	478	308
<i>1,000 employees</i>										
Labor migration to nonagricultural sectors*.....	— 7	3	7	8	1	12	4	4	6	— 1

\* Computed as the difference between agricultural employment in year  $t + 1$  and agricultural employment in year  $t = 1954, \dots, 1963$ .

of the economy.<sup>39</sup> Income and value added in agriculture are practically equal—that is, the age distribution of capital stocks in agriculture is almost equal to a stationary distribution; consequently, replacement flows and depreciation charges are nearly equal.

Similarly, the migration of labor off farms took place despite an increase in agricultural production. However, the

number of workers leaving agriculture during the analyzed period was relatively small and perhaps insignificant in the context of the general growth process.

In view of these results, it seems reasonable to conclude that the historical role of agriculture in supporting growth was almost completed by the early 1950's.

## Characterization of the Capital Formation and Trade Relations—the von Neumann Path

### The role of characterization

A multisectoral approach to the analysis of economic growth views the economy as a system of interacting sectors. The nature of the various interactions is defined in the behavioral, technical, and definitional relations making up the economic structure.

Economic structures are complex theoretical constructs. This is a fact which no realistic multisectoral analysis can escape. Thus, in our model of the

California economy, the number of structural parameters is counted in the thousands. Though cumbersome from the computational point of view, the multiplicity of parameters is not in itself a hindering factor in testing hypotheses or predicting future behavior. Nevertheless, it is still desirable to develop a characterization of the principal performance characteristics of the system in terms of as few parameters as possible. In particular, if this goal is

<sup>39</sup> The fluctuations in "net investment in agriculture" are partly due to our method of estimation which is based on changes in output. Thus, random variations in yields are reflected in investment figures.

attainable, then one could conceive of a systematic typology of economic structures. Furthermore, by comparing actual economic performance with the "characteristic performance," it should be possible to shed light on the function of external forces as determinants of economic behavior.

In the following, we propose to adopt the rate of growth, product mix, and supporting prices associated with the von Neumann path of maximal proportional growth (extended to include trade relations) as the principal characterizing parameters of the system.

This characterization is interesting in the positive sense whenever our behavioral system is endowed with stability properties conducive to a long-run balanced growth. From a normative point of view, certain "turnpike" theorems assure us that efficient growth paths of economies of the kind presently investigated will be in the neighborhood of von Neumann's path "most of the time," provided the planning period is sufficiently long. See, for instance, Koopmans (1967) and Radner (1961). In terms of our own study, the envisaged characterization will provide indicators concerning the maximal rate of growth attainable by the California economy without capital import, the relative importance of the various sectors, and their comparative advantage in trade with reference to the process of capital accumulation. Information on the von Neumann

path will also be helpful in analyzing the efficient growth path presented later. In particular, the relations between the turnpike and efficient growth paths of the economic system subjected to exogenous influences may provide a better understanding of optimal development programs.<sup>40</sup>

### The von Neumann path of maximal proportional growth

We shall consider an economy whose general structure resembles that described on pages 5 ff. There are, however, two major exceptions: First, the current account is forced to be balanced; that is, no interregional capital movements are permitted. Second, the role of labor and other primary resources is ignored. These are very restrictive assumptions. However, because our interest is in the characterization and not in the description or planning of actual economic performance, the assumptions should not be judged solely by their realism.<sup>41</sup>

Economic models used in deriving von Neumann's path of proportional growth ordinarily represent closed economies. Nevertheless, a trading economy can be fitted within this framework by defining a new commodity—foreign exchange. It is possible, then, to regard imports as activities utilizing foreign exchange to produce the imported goods and exports as activities utilizing the exported goods to produce foreign exchange. The re-

<sup>40</sup> Other uses of the von Neumann path have been proposed. Thus, Weil (1967) suggested that this characterization could be used for international comparisons of productivity and "comparative advantage" of trading countries.

<sup>41</sup> Tsukui (1968) used the turnpike theorem, which is based on similar assumptions, to derive optimal development plans for Japan. The exclusion of labor from his model was justified by arguing that "... the effect of technological progress appears in the reduction of labor input coefficients, while input-output and stock-flow matrices remain invariant, and as a result labor is not a scarce factor for the Japanese economy . . ." (p. 172). Tsukui seems to confuse scarcity with a uniform labor-augmenting technological change, which, if proceeding at the von Neumann rate of growth, will not affect the solution and may, thus, be ignored. In any event, labor scarcity cannot be disregarded in the California economy, and labor productivity does not change uniformly in all sectors.

duced balanced equations may now be rewritten as follows:<sup>42</sup>

$$\begin{bmatrix} I & I_M & \\ \hline & & V'_E \\ \hline & & \end{bmatrix} \begin{bmatrix} X_t \\ \hline M_t \\ \hline E_t \end{bmatrix} = \begin{bmatrix} A & & I_E \\ \hline & & V'_M \\ \hline & & \end{bmatrix} \begin{bmatrix} X_t \\ \hline M_t \\ \hline E_t \end{bmatrix} + \begin{bmatrix} CU' & & \\ \hline & & \\ \hline & & \end{bmatrix} \begin{bmatrix} X_t \\ \hline M_t \\ \hline E_t \end{bmatrix} \quad (18)$$

$$+ \begin{bmatrix} B & & \\ \hline & & \\ \hline & & \end{bmatrix} \begin{bmatrix} \Delta X_t \\ \hline \Delta M_t \\ \hline \Delta E_t \end{bmatrix} + \begin{bmatrix} I & -I_M & I_E \\ \hline & & V'_M - V'_E \\ \hline & & \end{bmatrix} \begin{bmatrix} C_o \\ \hline M_o \\ \hline E_o \end{bmatrix}$$

where the matrices  $A$  and  $CU'$  were defined on pages 5 ff;  $B$  is a matrix of capital coefficients,  $B = WL$ ;  $V'_{M(1 \times N_M)}$  and  $V'_{E(1 \times N_E)}$  are row vectors with unit elements; and  $I_{M(N_X \times N_M)}$  is a matrix with ones at the intersections of rows and columns corresponding to the imported goods and zeros everywhere else.  $I_{E(N_X \times N_E)}$  is similarly defined. Notice that  $N_X$ ,  $N_M$ , and  $N_E$  now represent the numbers of production activities, import activities, and export activities, respectively.  $X_{t(N_X \times 1)}$ ,  $M_{t(N_M \times 1)}$ , and  $E_{t(N_E \times 1)}$  are defined as on pages 5 ff. The same vectors with a subscript  $o$  represent autonomous consumption and exogenously determined imports and exports.

The augmented matrix on the left-hand side of equation (18) will be denoted by  $\hat{I}$ ; and the augmented matrices on the right will be denoted, successively, by  $\hat{A}$ ,  $\hat{CU}'$ ,  $\hat{B}$ , and  $\hat{D}$ . Equation (18) may now be rewritten:

$$\hat{T}\hat{X}_t = \hat{B}\Delta\hat{X}_t + \hat{D}\hat{X}_o \quad (19)$$

where

$$\hat{T} = \hat{I} - \hat{A} - \hat{CU}'$$

has dimensions  $(N_X + 1) \times (N_X + N_M + N_E)$  and

$$\hat{X}_t = \begin{bmatrix} X_t \\ M_t \\ E_t \end{bmatrix}$$

is  $(N_X + N_M + N_E) \times 1$ . The capital restrictions are explicitly recognized; that is:

$$\hat{B}\hat{X}_t \leq K_t \quad (20)$$

where  $\hat{K}_{t((N_X+1) \times 1)}$  is the vector of capital stocks at the beginning of the  $t$ th period by industry of origin.<sup>43</sup>

The model can be further specialized by stating the following properties of the matrices:

- Each commodity is either producible or importable or both.
- Each tradable commodity is either exportable or importable but is never both importable and exportable. Some commodities are non-tradable and are produced and consumed domestically only.
- Let  $(\hat{T}_o, \hat{B}_o)$  be a subset of  $N_X + 1$  activities of the set of all activities.

<sup>42</sup> The matrix  $M$  is omitted in this formulation, and  $A$  is to be understood as including  $M$ . That is, one of the sectors (UC 28 in the present study) is the noncompetitive imports sector.

<sup>43</sup> Since the present analysis is performed in terms of nonmonetary models, no stock of foreign exchange is ever carried. Hence, all coefficients in the last row of  $\hat{B}$  as well as the last element of  $\hat{K}_t$  are identically equal to zero.



We shall refer to  $(\hat{T}_\sigma, \hat{B}_\sigma)$  as a *producible selection* if, for each commodity, it includes either a production or an import activity. Thus, each producible selection includes a single export activity. Let  $\Sigma$  denote the set of all possible producible selections. Then, all producible selections are such that  $T_\sigma^{-1} \gg 0$  for all  $\sigma \in \Sigma$ .<sup>44</sup>

- d.  $\hat{B}_\sigma > 0$  for all  $\sigma \in \Sigma$ . Since foreign exchange is not used as a capital good (that is, we ignore demand for liquidity),  $\hat{B}_\sigma$  is always singular.
- e. Commodities can be disposed of without cost.

The above properties are all satisfied in the present analysis. In fact, one expects these properties to hold in most empirical input-output models.

In Appendix A it is shown that a maximal growth path involves an *extreme point* consisting of some producible selection  $(\hat{T}_\sigma, \hat{B}_\sigma)$  with all other activities set at a zero level.

Let the *stationary solution* corresponding to a maximal growth path be

$$\bar{X}_\sigma = \hat{T}_\sigma^{-1} \hat{D} \hat{X}_\sigma. \quad (21)$$

$\bar{X}_\sigma$  is a vector whose elements are the levels of activities in  $(\hat{T}_\sigma, \hat{B}_\sigma)$ . At these levels, no growth takes place, that is  $\Delta \hat{X}_t = 0$ .

Let  $W_\sigma$  be a  $(N_X + N_M + N_E) \times 1$  vector such that the values of  $w_{i\sigma}$  are equal to the corresponding values in  $\bar{X}_\sigma$  if the  $i$ th activity is in the producible selection  $\bar{\sigma}$ ; and if the  $i$ th activity is excluded from the producible selection  $\bar{\sigma}$ , then  $w_{i\sigma} = 0$ . Define:

$$W_t = \hat{X}_t - W_\sigma.$$

We shall consider only nonnegative values of  $W_t$ . Then, equation (19) may be written:

$$\hat{T} W_t = \hat{B} \Delta W_t \quad (19a)$$

since  $\hat{T} W_\sigma = \hat{D} \hat{X}_\sigma$ . Equation (20) can now be written

$$\hat{B} W_t \leq K_t - K_\sigma \equiv F_t \quad (20a)$$

where  $K_\sigma = \hat{B} W_\sigma$ . We can then define the following *transformation set* in the  $2N_X$  dimensional vector space:

$$S = \left\{ \left( \frac{F_{t+1}}{F_t} \right) : F_{t+1} \leq \hat{T} W_t + F_t \right. \\ \left. \text{and } \hat{B} W_t \leq F_t \text{ for some } W_t \geq 0 \right\}.$$

Given properties (a) to (e), the transformation set,  $S$ , satisfies the following conditions:

- i.  $S$  is a closed convex polyhedral cone in the nonnegative orthant of  $E^{2N_X}$ .
- ii. The disposal activity is costless.
- iii. It is impossible to produce something from nothing.
- iv. Every commodity can be produced.<sup>45</sup>

By virtue of properties (a) to (e), the above conditions are satisfied by the subsets  $S_\sigma$ , ( $\sigma \in \Sigma$ ) of  $S$ , which are based on the producible sets of activities  $(T_\sigma, \hat{B}_\sigma)$ .

By some well-known theorems we know that, since  $S$  satisfied (i) to (iv), there exists a von Neumann path of maximal proportional growth

$$F_{t+1}^* = \lambda^* F_t^* \quad (22)$$

<sup>44</sup> We shall adopt the following notations:  $X \geq 0$  implies all  $x_{ij} \geq 0$ ,  $X > 0$  implies all  $x_{ij} \geq 0$  with at least one  $x_{ij} > 0$ , and  $x \gg 0$  implies all  $x_{ij} > 0$ .  $\hat{T}_\sigma^{-1} \gg 0$  whenever  $\hat{A} + C\hat{U}'$  is indecomposable and has a spectral radius smaller than unity (Karlin, 1962, Chapter 8).

<sup>45</sup> Import and export activities are now regarded as ordinary productive activities, and foreign exchange is treated as an ordinary commodity.

TABLE 22  
AUTONOMOUS CONSUMPTION AND IMPORTS, EXOGENOUS EXPORTS, AND  
COMPOSITE TRADE ACTIVITIES CALIFORNIA, 1954

UC sector	Autonomous consumption $C_o=1954$	Autonomous imports $M_o$	Exogenous exports $E_o$	Restricted trade	
				Composite im- port	Composite ex- port
	1,000 dollars			dollar per dollar†	
1.....	3,373	197,085	‡	— .020871	
2.....	98,592				.001451
3.....	9,997				
4.....		20,186		— .002138	
5.....			227,897		
6.....	147,134				.125267
7.....	28,250				.044117
8.....	5,978				.096275
9.....		2,352		— .000249	
10.....			44,614		
11.....	154,672	34,714		— .008676	
12.....	473,636	151,841		— .016080	
13.....	456,150	75,825		— .008030	
14.....	229,317				.732890
15.....	909,195	141,976		— .015035	
16.....	48,720	405,848		— .042978	
17.....	— 665,716		601,456		
18.....	— 339,470	2,409,882		— .255199	
19.....			4,103,078		
20.....	— 706	716,675		— .075894	
21.....	497,418	1,826,231		— .193393	
22.....			155,609		
23.....	— 205,791	78,075		— .008268	
24.....	— 618,275		552,025		
25.....			264,277		
26.....	—1,257,104		120,000		
27.....		8,266		— .000875	
28.....				— .357314	
29-30.....					
31.....					
32.....					
37*.....					
41.....					
Total.....	— 29,630	6,068,956	6,068,956	—1.000000	1.000000

† Dollar of export or import originating in sector  $i$  per dollar total value of export or import.  
‡ Blanks indicate zero.

where  $F_t^*$  is the von Neumann vector of stocks and  $\lambda_t^*$  is the von Neumann growth coefficient (Karlín, 1962, Chapter 9). There also exists a vector  $P^* \gg 0$  of supporting prices such that

$$P^*F_{t+1} \leq \lambda^*P^*F_t \text{ for } \left(\frac{F_{t+1}}{F_t}\right) \in S \quad (23)$$

and

$$P^*F_{t+1}^* = \lambda^*P^*F_t^*.$$

Corresponding to von Neumann stocks

vector  $F_t^*$ , there are output vectors  $W_t^*$  and  $\hat{X}_t^* = W_t^* + W_o$ . Since the  $S_\sigma$  ( $\sigma \in \Sigma$ ) also satisfy (i) to (iv), similar solutions exist for any producible selection ( $\hat{T}_\sigma$ ,  $\hat{B}_\sigma$ ),  $\sigma \in \Sigma$ . A computational procedure for deriving  $W_t^*$  and  $P^*$  is presented in Appendix A.

von Neumann growth paths for  
the California economy, 1954

The algorithm presented in Appendix A was used to calculate two proportional growth paths for the California

economy: (1) proportional growth with unrestricted trade and (2) proportional growth with restricted trade.

Strictly speaking, the term "proportional" now applies to the  $W_i$  space and not to the  $X_i$  space.

The two alternative paths were calculated with reference to the same vector of autonomous consumption and imports and exogenous exports. This vector was calculated for 1954, with autonomous consumption set equal to the values of the intercepts of the consumption function multiplied by California population in 1954. All exports by UC 5, UC 10, UC 17, UC 19, UC 22, UC 24, UC 25, and UC 26 were regarded as exogenous exports.<sup>46</sup> The selection of autonomous imports was arbitrary and was based on the assumptions that the value of autonomous imports is equal to the value of exogenous exports and that the composition of autonomous imports resembled that of total imports in 1954. The resulting values of  $C_o N_{1954}$ ,  $M_o$ , and  $E_o$  are given in table 22.

**Maximal proportional growth path with unrestricted trade.** This path was derived under a relatively wide range of choice among trade activities. The possible export activities comprised exports originating in UC 6, UC 7, UC 8, and UC 14. (All other exportables were regarded exogenous.) The possible import activities included imports by UC 1, UC 3, UC 4, UC 11, UC 12, UC 13, UC 15, UC 16, UC 18, UC 20, UC 21, and UC 28. Each of the importables, except UC 28, was producible domestically.

**Maximal proportional growth path with restricted trade.** This path was obtained under the assumption that all controllable imports had to maintain the same proportion as in 1954; levels of all export activities were similarly con-

strained. Consequently, all controllable import and export activities were collapsed into one composite import activity and one composite export activity. These activities are also listed in table 22. The set,  $\Sigma$ , of producible selections, therefore, included only one selection; and the path was calculated in a single iteration.

To obtain points corresponding to 1954 conditions on each of the two paths, levels of output were computed as follows: The labor requirement of the stationary output levels,  $W_o$ , was first calculated using 1954 labor coefficients. The labor requirement for the stationary outputs was then subtracted from total civilian employment in 1954, and the elements of  $W^*_{1954}$  were set at the levels determined by the residual labor force along the von Neumann path of proportional growth.

The resulting rates of growth, levels of outputs, and resource utilization are presented in table 23. The corresponding supporting prices are listed in table 24.

**Rates of Growth and the Structure of Output.** Two rates of growth are given for each von Neumann growth path. The first is the von Neumann rate of growth,  $\alpha^* = \lambda^* - 1$ , in the  $W_i$  space; the other measures the rate of growth of the state income. The observed difference between the two measures is significant. It is related to the level of state income generated by the variables  $W_i^*$  as compared to the state income generated by the stationary outputs,  $W_o$ . In particular, if the income generated by  $W_o$  is large relative to income generated by  $W_i^*$ , then the rate of growth of the state income will be lower than the von Neumann rate. If, however, the income generated by  $W_o$  is negative, and this may happen when the effects of autonomous imports (direct and indirect) are

<sup>46</sup> The reasons for selecting these particular exogenous exports are spelled out on page 60.

TABLE 23

DOMESTIC STATE INCOME, RATES OF GROWTH, OUTPUTS BY UC SECTORS,  
AND RESOURCE UTILIZATION ON THE VON NEUMANN GROWTH PATH  
UNDER UNRESTRICTED AND RESTRICTED TRADE; AND ACTUAL 1954  
VALUES; CALIFORNIA, 1954

Variable	von Neumann growth path				Actual 1954 values
	Process $W^*_{1954}$		Process $X^*_{1954}$		
	Unrestricted trade	Restricted trade	Unrestricted trade	Restricted trade	
Domestic state income (million dollars)	†		30,204	30,162	30,297
Rates of growth (per cent)	4.916	3,469	3.705‡	2.352‡	6.2‡
Out puts by UC sectors (million dollars)					
1.....	310¶	316	392¶	439	337
2.....	133	121	315	318	312
3.....	114¶	117	343¶	368	344
4.....	41¶	74	127¶	195	198
5.....	45	44	266	272	284
6.....	1,120§	189	1,837§	442	488
7.....	37	148	143	298	340
8.....	8	70	73	160	137
9.....	4	118	10	218	181
10.....	105	114	260	285	295
11.....	84	117	352	431	404
12.....	561	528	1,004	1,096	1,026
13.....	125	119	595	603	571
14.....	94	580	364	1,028	1,221
15.....	534	545	1,695	1,783	1,727
16.....	1,177	1,132	997	1,100	865
17.....	2,332	2,097	4,010	4,011	2,861
18.....	5,019	4,580	3,142	3,233	3,998
19.....	36	32	4,553	4,554	4,550
20.....	1,935	1,808	960	1,050	896
21.....	5,433	5,000	5,086	5,220	4,610
22.....	158	143	297	298	306
23.....	1,545	1,422	1,627	1,682	1,589
24.....	3,365	3,031	4,384	4,390	4,434
25.....	6,084	5,450	8,070	8,045	8,153
26.....	8,535	7,702	10,025	10,065	10,213
27.....	267	265	224	264	229
28.....	595¶	658	712¶	888	580
29-30.....	4,231	3,640	4,862	4,632	6,468
31.....	3,093	2,803	3,938	3,976	3,963
32.....	4,282	3,880	5,465	5,504	5,479
37*.....	242	218	322	321	323
Resource utilisation					
Total labor (employees)	3,813,569	3,429,863	4,859,000	4,859,000	4,859,000
Total cropland (acres)	2,565,625	6,269,022	5,404,074	13,495,596	13,229,708
Water (acre-feet)	1,060,284	11,872,516	13,339,812	24,937,668	23,640,000

† Blanks indicate not calculated.

‡ Rates of growth of state income.

¶ In the "unrestricted trade" path, the figures for UC 1, UC 3, UC 4, and UC 28 are imports. There is no production in these sectors.

§ In the unrestricted trade path, the only export originates in UC 6.

stronger than those of the exogenous exports, then the rate of growth of the state income will be greater than the von Neumann rate.<sup>47</sup> As it happens, the dominant exogenous export in the California economy in 1954 was aircraft and parts [UC 19] which is a high-income generator. Consequently, the total income generated by the stationary outputs is high. Furthermore, the labor force required to support the stationary outputs is also large so that the outputs and income generated by  $W^*$ , which depend on the residual labor, are lowered. This can be verified by comparing the labor requirements presented in table 23. Here, we have a very significant characteristic of the California economy—namely, the high dependence of the state's rate of growth on development in its export markets. A slowdown in the demand for aircraft and parts may have deleterious effects on the rate of growth of the state's economy unless there are compensating changes in other exports and in import substitution.

The rates of growth presented in table 23 further substantiate an earlier assertion that the observed high rate of capital accumulation could not have been supported by domestic savings alone. Even if we assume that changes in autonomous consumption and imports and in exogenous exports would permit the state income to grow at the von Neumann rate, and even if we allow for the flow inputs augmenting technological change, the economic growth rate could hardly exceed 4.5 per cent.<sup>48</sup> Only the restricted trade path is hereby considered because it reflects many effective

restrictions ignored in deriving the unrestricted trade path. The observed growth rate of 6.2 per cent, therefore, must have been supported by imported capital.

The difference in the rates of growth between the restricted trade and unrestricted trade paths is not meaningful in the present characterization because the unrestricted trade is unrealistic.

Comparing the output structure of the von Neumann path with restricted trade to the actual 1954 structure reveals a remarkable resemblance, but also some important divergencies. Because the economy was in actuality growing at a higher rate than the von Neumann rate, the capital good sectors [UC 18 and UC 29–30] were considerably larger in reality than in the von Neumann solution with restricted trade. Along with this is a divergency in trade relations which, in fact, involved a big import surplus, while in the adopted characterization the current account was balanced.<sup>49</sup> In view of this analysis, it would seem that, *in the absence of substantial capital movements, the economy tends to grow along the von Neumann path with restricted trade.* If true, this characterization could serve as an important tool for long-range projections.

**von Neumann supporting prices.** The prices presented in table 24 may be interpreted as the marginal contribution of a unit of output originating in each sector to the rate of growth in terms of the amount of foreign exchange required to produce the same marginal contribution. If the price is greater than unity, then replacing domestic production by imports will raise the rate of growth; and

<sup>47</sup> Since the intercepts of the consumption function add up to the low value of .002924 (table 23), autonomous consumption exerts a neutral influence on the amount of income generated by the stationary outputs. Thus, in 1954 autonomous consumption added up to only \$30 million (table 22).

<sup>48</sup> 3.5 per cent caused by capital accumulation and 1.0 per cent by flow inputs augmenting technological progress.

<sup>49</sup> An unbalanced current account could be forced on the characterization through certain modifications in the autonomous imports and exports.

TABLE 24  
SUPPORTING VON NEUMANN PRICES  
UNDER UNRESTRICTED AND  
RESTRICTED TRADE  
CALIFORNIA, 1954

UC sector	Supporting prices†	
	Unrestricted trade	Restricted trade
	dollars per dollar output	
1.....	1.000000	1.531698
2.....	1.007826	1.069641
3.....	1.000900	1.176883
4.....	1.000000	1.306022
5.....	1.134914	1.083684
6.....	1.000000	.972086
7.....	1.122839	1.073168
8.....	1.078259	1.028001
9.....	1.624315	1.540974
10.....	1.051694	1.015077
11.....	.987878	1.097584
12.....	.984751	1.295391
13.....	.979515	1.089085
14.....	1.012797	.996403
15.....	.983237	1.054769
16.....	.974883	.991897
17.....	.976949	.942021
18.....	.967632	.972061
19.....	.958389	.952910
20.....	.990219	1.099921
21.....	.952189	.936559
22.....	.957905	.934025
23.....	1.092355	1.027120
24.....	.948628	.936168
25.....	1.002536	.965857
26.....	1.026385	.961319
27.....	1.005596	1.090928
28.....	1.000000	1.984352
29-30.....	.948880	.935910
31.....	.943882	.916920
32.....	.919347	.950301
37*.....	.886213	.870346

† In terms of the price of foreign exchange.

conversely, if the price is less than unity, the good should be produced domestically and, perhaps, exported. Had both

imports and exports been feasible in all sectors, all prices cited in the table would equal 1. However, this degree of freedom is not permitted even in the so-called unrestricted trade. Consequently, most listed prices are different from unity, the discrepancies being more pronounced under restricted trade.

The prices associated with the restricted trade solution suggest that all primary and processed agricultural products, except vegetables [UC 6] and canning, preserving, and freezing [UC 14], are at a comparative disadvantage. However, with unrestricted trade, the competitive position of agricultural processing is reversed. Utilizing imported raw materials, it becomes advantageous to process agricultural products domestically. (See also pages 66 ff.) Table 24 also suggests that domestic production of meat animals and products [UC 1], farm dairy products [UC 3], food and feed grains [UC 4], and forage [UC 9] is costly; and if feasible, these products should be imported. Similarly, of the controllable export activities, vegetables [UC 6] have the lowest cost of production. In fact, the unrestricted path includes UC 6 as the sole controllable exports.

The von Neumann prices characterization of the economy thus provides indications concerning the comparative advantage of the various sectors in the context of trade and growth.

## An Efficient Program of Investment and Trade for the California Economy, 1955-1961

### Scope and objectives

Our multisectoral model of the California economy is not closed. There are the "open end" variables  $I_t$ ,  $E_t$ ,  $M_{ct}$ , and  $D_{t-1}$  whose values must somehow be determined in order to have a determi-

nate equilibrium. In this section we shall regard the open-end variables as *control variables* whose values are set with the aim of optimizing, in some sense, the growth performance of the economy.

In fact, most of the control variables

considered were not subject to centralized decision-making by public authorities. Under the social organization prevailing during the analyzed period, only levels of investment in water resource development programs were decided primarily in the public sector. The levels of the other control variables, though indirectly influenced by political decisions, were determined in the private sector. Thus, our main objective is to produce a development program which may serve as a norm of comparison by which the actual performance of the economy may be judged and not to design a plan that would furnish a blueprint for action by all economic agents in the system. Nevertheless, there is a considerable interest in the planning methodology employed in the present analysis. In this respect, one may regard the present attempt to obtain an efficient growth program as an experiment in economic programming. The experimental results may shed light on the scope and limitations of the programming technique employed in the present analysis.

Investment in water resource development is decided mostly in a political process. The economic considerations involved in water development decisions have, hitherto, assumed the form of a cost-benefit analysis in which market prices and interest rates have served as indicators of consumer preferences, production constraints, and trade opportunities. A benefit-cost analysis is based essentially on a partial equilibrium approach dealing primarily with inputs and outputs closely related to the water resource system. Relations with more remote sectors of the economy are assumed to be reflected in the prices used in the analysis.

Several economists (f. i. Eckstein,

1958, and Marglin, 1962 and 1967) have argued that optimal investment programs should be defined with reference to the objective functions of policy-makers, and this should be reflected in cost-benefit analyses. However, market imperfections, externalities, and, at times, the absence of explicit pricing often distort the results of cost-benefit analyses, thus diminishing their usefulness in decision-making.

An optimal overall development program may provide an alternative approach which is based on a general equilibrium analysis.

### The objective function and efficient programs

Any concept of optimality is defined with reference to some objective function. The question then arises: What is the appropriate objective function for the present analysis?

To minimize the amount of value judgment inherent in setting up social goals, we shall ignore the distributional and possible noneconomic policy objectives.<sup>50</sup> Given this simplification, it was suggested that an appropriate objective function would consist of the present value of future consumption streams discounted at the "social rate of interest." This rate reflects society's time preference and its concerns with the well-being of future generations, and is, thus, presumed lower than the market rate (Marglin, 1962 and 1967).

This approach gives rise to two practical problems: First, it presupposes a knowledge of the social rate of interest, which is, somehow, determined in a political process. Second, with finite planning horizons, one also faces the problem of how "end conditions" (terminal capital capacities in the present

<sup>50</sup> This does not mean that the resulting plan is devoid of noneconomic implications or that all alternatives considered are identical in this respect. We simply pretend that these implications are negligible, clearly an untenable pretension.

study) will affect the consumption stream in the years following the planning horizon.

Lacking information on the social rate of interest and being unable to deal with the postplanning period, we had to settle for an approach leading to the class of *efficient* programs rather than to a single optimal program.

In terms of consumption streams, a program is efficient if it is impossible to increase consumption in any year without decreasing it in any other year. This holds for a program with an infinite horizon. Consider now a finite planning period. If primary resources are not the only effective constraints, the postplanning period consumption stream is an increasing function of the size of capital stocks at the end of the planning period. Therefore, any program that maximizes these stocks for some efficient consumption stream during the planning period is an efficient program. Notice, however, that so far we have ignored the problem of terminal stocks composition. The efficient composition depends on the postplanning period relations on which we have no information. Actually, all the required information concerning the postplanning period years is summarized in the shadow prices of the terminal capital stocks (in the finite program) that are associated with the efficient infinite consumption program. These are not known to us.

In the absence of effective primary resources constraints and exogenously varying trade variables and capital movements, this is not a critical difficulty because, according to the "turnpike theorem," all efficient paths of capital accumulation approach the von Neumann path of proportional growth and spend most of the planning period in its neighborhood regardless of the prices of

terminal stocks and the levels of initial stocks (Tsukui, 1966). "Therefore, the wisest course . . . is to abstain from worrying about the choice of  $P$  (the shadow prices of capital stocks,  $P.Z.$ ) and to plan to lead the economy efficiently toward the turnpike" (Tsukui, 1968, p. 174). This can be achieved by finding a feasible program that will maximize the levels of the terminal stocks subject to the constraint that they are on von Neumann's growth path.<sup>51</sup>

In the present analysis, growth is effectively restricted by labor availability and other primary resources. Also, both exogenous exports and unilateral capital transfers exert external influences on the efficient programs, thus preventing them from converging to the von Neumann path. We would like to propose a conjecture that, even under the analyzed conditions, there exists a path to which all efficient paths converge as the planning period is lengthened. This "displaced turnpike" is not necessarily a ray in the space of capital capacities. Yet, if it is in the proximity of some ray for a sufficiently long interval, then Tsukui's approach, cited above, may be adopted in the present analysis. Alternatively, one would have to use an arbitrary set of prices to value the terminal stocks. If the actual growth of the economy is any indication, then the proximity of the displaced turnpike to a ray is perhaps sufficiently good; and the adoption of Tsukui's approach would appear preferable to the selection of an arbitrary set of prices. The objective function employed in the present study reflects this preference.

### A linear programming formulation

The linear structure of the model and the objective function allow us the use of linear programming techniques in

<sup>51</sup> The path can always be reached if disposal is costless as has been assumed. The planning period, however, should be sufficiently long to allow for an efficient convergence to the turnpike.



obtaining the desired efficient programs. In terms of the model and notations presented, the linear programming problem is:

$$\text{Maximize} \left( x_o - \epsilon \sum_{t=1}^T D \right)$$

subject to the following constraints

$$x_o g - \sum_{t=1}^T I_t^o \leq K_1 \quad (24)$$

$$-x_o g_D + D_t^d \leq 0 \quad (24a)$$

$$TX_t + rCD_{t-1}^d - rCD_{t-1}^c - WI_t^o \quad (25)$$

$$-E_t + M_{ct} \geq C_o N_t + E_{ot}$$

$$LX_t - \sum_{t=1}^{t-1} I_t^o \leq K_1 \quad (26)$$

$$RX_t \leq L_t \quad (27)$$

$$V'MX_t + V'M_{ct} - V'E_t + (1+r)D_{t-1}^d - (1+r)D_{t-1}^c \quad (28)$$

$$-D_t^d + D_t^c = H_t + V'E_{ot}$$

$$M_{c, 41, t} - E_{42, t} - E_{43, t} \leq 0 \quad (29)$$

$$x_o, X_t, I_t^o, D_t^d, D_t^c, E_t, M_{ct} \geq 0 \quad (30)$$

$$t = 1, 2, \dots, T.$$

All matrices are augmented and comprise both primary and auxiliary sectors.<sup>52</sup> Additionally, matrix R now contains three direct output restrictions to be explained subsequently.  $\epsilon$  is a small, arbitrary, positive number introduced in order to prevent linear dependency among columns corresponding to  $D_t^d$  and  $D_t^c$ ;  $g$  is a vector with nonnegative elements adding up to one. They represent the required ratios among terminal capi-

tal stocks.  $g_D$  is a coefficient determining the permissible ratio of the state debt to total capital stocks.  $D_t^d$  is the state's outstanding debt, and  $D_t^c$  is the state's outstanding credit.  $E_{ot}$  now denotes the exogenous exports, and  $V$  is a column vector of ones.

$x_o$ , therefore, represents the "length" of the vector of terminal stocks along the ray defined by  $g$ . If, in fact, the strict equality in equation (24) holds, then  $x_o g$  is the vector of terminal stocks. The program maximizing  $x_o$  leads to a point in the efficiency set of terminal capital stocks. Also, notice that, because  $I_t^o \geq 0$ , by equation (30), no decrease in capital stocks is permitted. These relationships are illustrated graphically for a two-commodity economy in figure 8.

The curve  $E_T(K_1)$  represents the efficiency set of terminal capital capacities and is dependent on the initial capacities,  $K_1$ . The ray defined by  $g$  is represented by the broken line through the origin and the time path of capital capacities associated with the efficient program by the curve  $P(K_1, g)$ . That is, the efficient path depends on the initial capital capacities and the required proportions among terminal capital capacities. Notice that  $P(K_1, g)$  is not necessarily a proportional growth path.

The detailed structure and dimensionality of the linear programming problem for a three-year program ( $T = 3$ ) is presented in table 25. In the present analysis, the efficient program spans a seven-year period. The extension of the linear programming tableau from three years to seven years is performed by repeating the annual subtables over the extended programming period.

Notice first that a small arbitrary value,  $-\epsilon$  ( $\epsilon > 0$ ), was introduced in the objective function in columns corresponding to  $D_t^d$  ( $t = 1, 2, 3$ ). This was

<sup>52</sup> The method of incorporating the auxiliary water and irrigation sectors into the model is described on pages 9 and 25.

TABLE 25  
A THREE-YEAR LINEAR PROGRAMMING TABLEAU\*

	$x_0$	First year						Second year						Third year						Type of constraint	Right-hand side
		$X_1$	$E_1$	$M_{e1}$	$I_1^v$	$D_1^d$	$D_1^c$	$X_2$	$E_2$	$M_{e2}$	$I_2^v$	$D_2^d$	$D_2^c$	$X_3$	$E_3$	$M_{e3}$	$I_3^v$	$D_3^d$	$D_3^c$		
Dimensions.....	1	36	6	12	30	1	1	36	6	12	30	1	1	36	6	12	30	1	1		
Equation Dimension																					
Objective function	1	1				$-\epsilon$						$-\epsilon$						$-\epsilon$		≡	Maximize
(24)	30	$\rho$			$-I$						$-I$						$-I$			≡	$K_1$
(24a)	1	$-\rho\hat{D}$																1		≡	0
First year																					
(25)	36	$T_1$	$-I_E$	$I_M$	$-W$															≡	$C_0N_1 + E_{e1}$
(26)	30	$L$																		≡	$K_1$
(27)	10	$R_1$																		≡ (≡)	$Z_1$
(28)	1	$V'M$	$-V_E'$	$V_M'$		-1	1													≡	$H_1 + V'E_{e1}$
(29)	1		$-V_{Ew}$	$V_{Mw}$																≡	0
Second year																					
(25)	36					$rC$	$-rC$	$T_2$	$-I_E$	$I_M$	$-W$									≡	$C_0N_2 + E_{e2}$
(26)	30				$-I$			$L$												≡	$K_1$
(27)	10							$R_2$												≡ (≡)	$Z_2$
(28)	1					$(1+r)$	$-(1+r)$	$V'M$	$-V_E'$	$V_M'$		-1	1							≡	$H_2 + V'E_{e2}$
(29)	1								$-V_{Ew}$	$V_{Mw}$										≡	0
Third year																					
(25)	36											$rC$	$-rC$	$T_3$	$-I_E$	$I_M$	$-W$			≡	$C_0N_3 + V'E_{e3}$
(26)	30				$-I$						$-I$			$L$						≡	$K_1$
(27)	10													$R_3$						≡ (≡)	$Z_3$
(28)	1										$(1+r)$	$-(1+r)$		$V'M$	$-V_E'$	$V_M'$		-1	1	≡	$H_3 + V'E_{e3}$
(29)	1														$-V_{Ew}$	$V_{Mw}$				≡	0

\*  $\epsilon$  = an arbitrarily small, positive number.  
 $I_E$  = a  $36 \times 6$  matrix with a unit element if the export corresponds to the row sector; otherwise, the element is zero.  
 $I_M$  = a  $30 \times 12$  matrix with a unit element if the import corresponds to the row sector; otherwise, the element is zero.  
 $V_E$  = a  $6 \times 1$  vector with a unit element if the export is by a principal sector and zero if it corresponds to an auxiliary sector.  
 $V_M$  = a  $12 \times 1$  vector with a unit element if the import is a principal good and zero if the import is water.  
 $V_{Ew}$  = a  $6 \times 1$  vector with a unit element if the export is water; otherwise, zero.  
 $V_{Mw}$  = a  $12 \times 1$  vector with a unit element if the import is water; otherwise, zero.  
 $T_i$  and  $R_i$  are defined as before the index  $i$  was added to represent technological change.

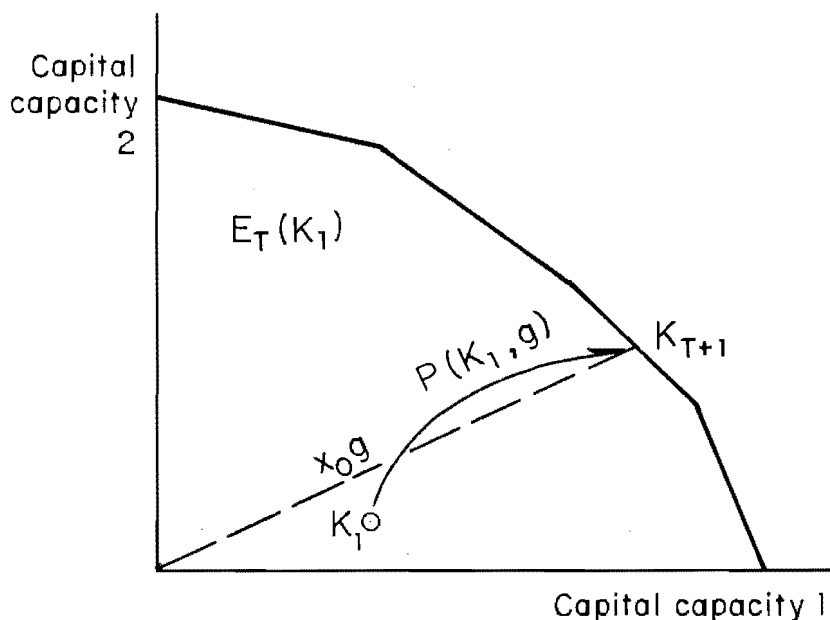


Fig. 8. A Graphic illustration of an efficiency program.

done to remove the dependency between  $D_t^c$  and  $D_t^d$  which might otherwise lead to an unbounded solution with infinite borrowing and lending.  $\epsilon$  is sufficiently small to have no economic significance. (In the actual computations  $\epsilon$  was assigned the value .0001).

In table 25 the matrices  $T$  and  $R$  are indexed by a subscript  $t$  referring to the year. Indeed,  $T$  and  $R$  vary with  $t$  as a result of technological progress.

**The expansion ray of capital capacities.** The set of inequalities (equations 24 and 24a) defines the ray in the space of capital capacities and borrowed capital along which economic expansion is being maximized. The values of  $g$  and  $g_D$  used in the seven-year programming period are given in table 26. To conform closer to a planning situation, these values were calculated on the assumption that the only known parameters are the annual rate of growth of NSP and population, the anticipated rates of change in exogenous exports, and the income elasticities of demand. Given these parameters, it was possible to

derive estimates of rates of growth of capital capacities by means of rather simple formulae. The composition of terminal capital capacities was then obtained by projecting 1954 capacities to the beginning of 1962. Notice that the expansion ray is in terms of the principal sectors alone. That is, capital capacities of auxiliary water sectors do not restrict directly the level of the objective function. The development program of the auxiliary sectors is thus designed merely to support general economic growth without being a goal in itself.

The manner by which the expansion ray for terminal capital capacity was determined implicitly assumed that the actual growth path is in the neighborhood of the displaced turnpike. This need not be true. Yet, as the time horizon of the program is extended into the future, the effect of deviations of terminal capacities from the displaced turnpike on the early phases of the program diminishes. Furthermore, given the notorious "runaway" habits of linear programming solutions, our approach may

endow the program with more realism—although, perhaps, at some apparent cost in efficiency.

TABLE 26  
COMPOSITION OF TERMINAL  
CAPITAL CAPACITIES, 1962, ALONG  
THE EXPANSION RAY AS COMPARED  
TO THE 1954 COMPOSITION OF  
THE SAME CAPACITIES,  
CALIFORNIA†

UC sector	Proportion of terminal capital capacities $g_t$ , 1962	Proportion of 1954 capital capacities $g_t$ , 1954
1.....	.005213	.005123
2.....	.002670	.002780
3.....	.006561	.006479
4.....	.002947	.002893
5.....	.004090	.005491
6.....	.002499	.002750
7.....	.006367	.006530
8.....	.002718	.003127
9.....	.002355	.002312
10.....	.004155	.004078
11.....	.001036	.001089
12.....	.002774	.002940
13.....	.001607	.001805
14.....	.006587	.007627
15.....	.011345	.012230
16.....	.005356	.005298
17.....	.032886	.035926
18.....	.032999	.032099
19.....	.020191	.040594
20.....	.009607	.009429
21.....	.032348	.032199
22.....	.003850	.003529
23.....	.078795	.075517
24.....	.034753	.032996
25.....	.201965	.198478
26.....	.467594	.450258
27.....	‡	
28.....		
29-30.....	.016732	.016423
31.....		
32.....		
37*.....		
Total.....	1.000000	1.000000
$g_D$ .....	.020000	

† The expansion ray was defined for primary sectors alone.

‡ Blanks indicate zero.

SOURCE: For 1954, calculated from capital stocks figures available in table 6. For 1962, derived as explained in text.

<sup>53</sup> If the strict equality in equation (24) holds,  $x_0$  is equal to the total value of accumulated capital stocks at the end of the  $T$ th year (1961 in the seven-year program). Let  $b$  denote the capital/NSP ratio; then, the permissible debt service charges/NSP ratio,  $\rho$ , implied by our constraints would be:

$$\rho = \frac{rD_t^d}{Y} \leq g_D r b.$$

In the present analysis  $\rho \leq (.02) (.065) (2.2) = .00286$ .

Table 28 shows that the specified composition of terminal capital capacities along the expansion ray does not diverge substantially from their composition at the beginning of 1954. However, the debt ratio,  $g_D$ , is considerably different. Whereas, in 1954 the outstanding state debt was assumed zero, at the end of 1961 we allow an outstanding debt of 2 per cent of the total value of capital stocks.<sup>53</sup> The value of  $g_D$  was determined arbitrarily. Some justification for allowing borrowing could, perhaps, rely on considerations similar to the ones raised in the analysis of the determinants of capital movement presented on pages 11 and 26 ff.

**The capital capacity constraints.** The set of inequalities, equation (26), restricts production in each industry not to exceed the sector's productive capacity. No direct information concerning the initial capacities (beginning of 1955) was available. Actual 1954 outputs, therefore, served as a point of departure. It was assumed that, by the beginning of 1955, the capital capacity of each sector was 10 per cent higher than the minimum required to support observed 1954 outputs. Since all outputs grew during 1954 by less than 10 per cent, the increase by 10 per cent implicitly assumes a slack of about 2-5 per cent in the form of idle capacity. The resulting estimates of capital capacities,  $K_{1i}$ , are presented in table 27.

Of the sectors listed in that table, UC 27, UC 28, UC 31, UC 32, and UC 37\* do not require capital. Also, since UC 41 has already been developed to its

TABLE 27

## ESTIMATED INITIAL CAPITAL CAPACITIES USED IN THE LINEAR PROGRAMMING CALIFORNIA, 1955

UC sector	Capital capacity $K_{11}$ 1,000 dollars of invested capital
1.....	417,804
2.....	226,769
3.....	528,473
4.....	235,926
5.....	447,853
6.....	224,327
7.....	532,587
8.....	255,020
9.....	188,563
10.....	332,616
11.....	88,833
12.....	239,780
13.....	147,254
14.....	622,063
15.....	997,450
16.....	431,685
17.....	2,930,183
18.....	2,618,048
19.....	3,461,377
20.....	769,068
21.....	2,026,170
22.....	320,200
23.....	6,159,207
24.....	2,691,145
25.....	16,188,051
26.....	36,723,702
27.....	†
28.....	
29-30.....	1,339,470
31.....	
32.....	
37*.....	
41†.....	
42.....	570,240
43.....	
51.....	745,220

† Blanks indicate zero.

† No capital capacity constraint for UC 41 was included in the analysis since its potential was fully developed. The primary resource constraint fully reflects the capital constraint.

full potential, its output is restricted by the appropriate primary resource constraint. Hence, there are only 30 sectors whose output is subject to capital capacity constraints.

**Primary resource constraints.** Inequality (equation 27) consists of seven constraints related to primary resources and

three direct output constraints. Levels of the various primary resources are listed in table 28. Notice that total civilian employment figures cited in that table are higher than actual civilian employment figures given in table 15 but lower than the civilian labor force. That is, frictional unemployment at the rate of 3.5 per cent was assumed to prevail throughout the programming period.

In addition to primary resource constraints, equation (27) includes three direct output constraints. Production of vegetables was restricted by annual output ceilings. Presumably, this restriction would in reality be enforced by the market through falling prices—a mechanism not explicitly allowed for in the present analysis.<sup>54</sup> The other two output constraints placed floors under the outputs of fruits and oranges [UC 7 and UC 8]. Presumably, the rate of decline in production of these sectors is dictated by the rate at which trees are removed without replacement. Since trees in full bearing are usually not removed, the rate of decline in output depends on the age distribution of groves.<sup>55</sup> The ceiling and floors on production are given in table 29. The figures presented in the table are somewhat arbitrary and based on judgment. However, in most years the direct output constraints were ineffective.

**Exogenous exports ( $E_{ex}$ ) and unilateral transfers ( $H_i$ ).** Exports originating in UC 5, UC 10, UC 17, UC 22, UC 24, UC 25, and UC 26 were regarded as exogenous for a variety of reasons. Thus, output of cotton [UC 5] was, to some extent, controlled by the federal government through acreage allotments while outputs of petroleum [UC 17] and other minerals [UC 22] were presum-

<sup>54</sup> The existence of falling demand functions for exports can be dealt with within the framework of linear programming at the cost of additional activities and constraints (Bruno, 1966). This was not done in the present analysis because the size of the problem was already painfully large.

<sup>55</sup> When trees are removed because of urbanization, the drop in production may be faster.

TABLE 28  
PRIMARY RESOURCE CONSTRAINTS IMPOSED IN THE LINEAR  
PROGRAMMING, CALIFORNIA, 1955-1961

Resource	1955	1956	1957	1958	1959	1960	1961
Total civilian employment (employees)	5,116,430	5,370,225	5,592,175	5,695,430	5,888,430	6,077,570	6,253,200
Nonfarm civilian employment (employees).....	4,731,430	4,988,225	5,217,175	5,328,430	5,522,430	5,723,570	5,903,200
Total harvested cropland (1,000 acres).....	12,547	12,547	12,547	12,547	12,547	12,547	12,547
Irrigable land (1,000 acres).....	10,712	10,712	10,712	10,712	10,712	10,712	10,712
Water potential, UC 41 (1,000 acre-feet).....	22,200	22,200	22,200	22,200	22,200	22,200	22,200
Water potential, UC 42 (1,000 acre-feet).....	8,600	8,600	8,600	8,600	8,600	8,600	8,600
Water potential, UC 43 (1,000 acre-feet).....	6,800	6,800	6,800	6,800	6,800	6,800	6,800

SOURCE: Appendix B, Primary Resources—Requirements, Utilization, and Availability.

ably determined by various resource extraction constraints which were not recognized explicitly in the formulation. It was, therefore, convenient to introduce these restrictions by regarding the exports from these sectors as exogenously given. Exports of aircrafts and parts were, in great measure, determined by purchases by the federal government, and the sector was, thus, truly exogenous. Similarly, it is reasonable to assume that exports by trade, transportation, and service [UC 24, UC 25, and UC 26] depend more on the national demand for these services than on endogenous factors within California. A combination of the above-mentioned considerations led to the treatment of exports by UC 10 as exogenous exports.

The estimated values of the exogenous

exports for the appropriate sectors and years are included in table 18.

Estimates of unilateral transfers of capital into California,  $H_t$ , for the appropriate years are included in table 19.

**Interest rate ( $r$ ).** The interest rate used in the present analysis was  $r = .063$ . It is based on information available in Romans (1965, p. 92).

**Dimensions of the linear programming tableau.** As can be seen from table 25, the number of constraints for given time horizon,  $T$ , is  $31 + 78T$ , and the number of activities is  $1 + 86T$ . The seven-year program thus consisted of 577 constraints and 603 activities.

**The primal solution**<sup>56</sup>

**Ah overview.** The solution values of the state's income, output and trade by

<sup>56</sup> The solution was obtained using IBM's linear programming code MPS-360.

TABLE 29  
DIRECT OUTPUT CONSTRAINTS IMPOSED IN THE LINEAR  
PROGRAMMING CALIFORNIA, 1955-1961

UC sector	Type of restriction	1955	1956	1957	1958	1959	1960	1961
1,000 dollars (1954 prices)								
6.....	IN IV IA	550,000	616,000	680,000	773,000	866,000	970,000	1,086,000
7.....		326,056	312,470	298,884	295,298	271,712	258,126	244,440
8.....		132,900	128,795	124,684	120,573	116,462	112,351	108,240

TABLE 30

**EFFICIENT LEVELS OF STATE INCOME, OUTPUT, AND TRADE BY BROAD  
SECTORS NET PRIVATE INVESTMENT AND THE STATE'S DEBT,  
CALIFORNIA, 1955-1961**

Variable	Base year, 1954 (actual)	1955	1956	1957	1958	1959	1960	1961
	<i>million dollars (1954 prices)</i>							
State income.....	30,297	31,749	34,948	37,905	39,854	42,534	45,084	47,397
Total primary agriculture								
Output.....	2,915	2,951	2,931	2,968	3,031	3,154	3,172	3,253
Export.....	575	540	649	725	817	940	943	896
Import.....	— 275	— 367	— 806	— 908	— 953	— 994	— 1,116	— 1,030
Agricultural processing								
Output.....	1,949	5,444	6,261	6,457	6,379	6,478	6,707	6,793
Export.....	327	949	922	848	600	475	343	56
Import.....	— 508	— 397	*		— 32	— 69		— 54
Other manufacturing								
Output.....	17,779	16,831	23,011	23,341	22,238	21,967	21,011	21,572
Export.....	4,704	4,525	4,979	5,297	4,556	4,455	3,883	3,617
Import.....	— 6,738	— 8,429	— 4,459	— 5,562	— 6,851	— 8,378	—10,512	—13,576
Other nongovernment (mining, utilities, services, trade, and construction)								
Output.....	31,715	33,854	33,847	37,154	41,031	45,094	49,901	52,636
Export.....	1,091	1,180	876	1,021	1,160	1,518	1,518	1,956
Import.....	109							
Noncompetitive import								
Import.....	— 580	— 816	— 923	— 947	— 971	— 1,010	— 1,046	— 1,095
Local, state, and federal govern- ment								
Output.....	9,443	9,906	10,961	11,778	12,325	13,107	13,863	14,656
Net private investment.....	6,002	6,889	3,253	4,164	6,352	8,034	11,304	15,639
State debt†.....		743	— 3,122	— 6,521	— 7,383	— 7,211	— 4,304	2,731

\* Blanks indicate zero.

† Negative values signify the state's credit.

broad economic sectors, and other economic indicators are presented in table 30.

Efficient levels of the state's income grew from \$30,297,000,000 in 1954 to \$47,397,000,000 in 1961—an annual rate of growth of about 6.6 per cent as compared to an observed rate of growth of 6.2 per cent. The difference is attributable in part to differences in the efficiency of resource allocation but chiefly to the fuller use of the labor force in the efficient program. In view of this, it

would seem that the contribution of increased efficiency to growth was rather limited.<sup>57</sup> Or, in other words, *disregarding the problem of unemployment, the allocative inefficiencies associated with the observed growth path were rather mild.*<sup>58</sup>

The solution values for primary agriculture involve some obvious trends. Production is increasing but at a lower rate than the rise in demand. Consequently, imports increase rapidly; and although exports also increase, the trade deficit of primary agriculture is on the

<sup>57</sup> The program maximizes capital capacities and not income. However, in the present formulation the rate of capital accumulation tends to increase with income.

<sup>58</sup> It was instructive to watch the intermediate calculations in the solution procedure. As the simplex algorithm progressed, it became obvious that relatively large divergencies in the composition of output, investment, and trade between the optimal and intermediate solutions involved relatively small differences in the objective function and the state's income, thus suggesting that perhaps the convex set of feasible solutions is not that convex!

rise. In reality, primary agricultural production was rising slowly and so were the net exports of primary agricultural products. The lag of production relative to demand was manifested in increased imports of processed agricultural products.

Output of agricultural processing is also increasing, but the efficient program involves a rapid overall reduction in the volume of trade with both exports and imports practically vanishing. In actuality only a slight decline in exports materialized, while imports showed considerable gains.

The efficient program of production and trade by other manufacturing sectors involves an increase in production accompanied by slowly declining exports and rapidly rising imports. That is, the increase in supply lags behind the rise in domestic demand. In reality the increase in imports was slower than in the efficient program. The difference is probably caused by the higher growth rate of income and capital capacities characterizing the efficient program. Under these conditions domestic demand for the outputs of all sectors rises faster than supply. Because nontradable and exogenous exports must be produced domestically, the tradable sectors will exhibit higher trade deficit. However, the steep increase in imports takes place only at the second half of the planning period. We shall reconsider this phenomena when we deal with the state debt and net private investment.

Because all other sectors of the economy (mining, utilities, services, trade and transportation, construction, and governments) are either nontradable or produce exogenous exports, their levels are endogenously determined according to the evolution of domestic and export demand for their outputs. They, therefore, tend to grow at the same pace as the economy in general.

Net private investment and the state debt in the efficient program exhibit the following behavior: In the first year of the planning period, all available capital resources, including domestic saving and unilateral transfers, together with some borrowed capital, are invested in domestic capital capacities in order to open capacity bottlenecks. However, in the following three years domestic investment is lower, and a rapid increase in lending takes place with the outstanding credit reaching a peak of \$7,383,000,000 in 1958. This trend is reversed thereafter. Apparently, the stock of capital in California at the beginning of 1955 was such that the internal rate of returns was driven down to 6.3 per cent after investing a certain portion of the saving and transferred capital. It is, then, more efficient to invest the rest abroad. The reversal of this trend toward the end of the period is, to a large extent, and "end of period" effect resulting from our particular formulation in which the amount of capital accumulated domestically is the optimization criterion. One wonders whether extending the planning period will not also extend the period during which lending, rather than borrowing, takes place. It is possible that, toward the end of the period, forces promoting borrowing (in the sense of the analysis on page 11) tipped off the scale in favor of borrowing. At any event, the observed behavior lends credence to the adopted estimate of the interest rate,  $r = .063$ , as an equilibrium value.

The efficient investment and borrowing schedule is correlated with the efficient trade program. The trade deficit in the "other manufacturing" sector closely follows the steps of the borrowing schedule.

**The primary agricultural sectors and water supply.** The efficient program of water supply and production and trade



TABLE 31  
EFFICIENT LEVELS OF OUTPUT AND TRADE BY PRIMARY AGRICULTURAL  
SECTORS, WATER SUPPLY, AND LAND UTILIZATION CALIFORNIA,  
1955-1961

UC sector or resource	Base year, 1954 (actual)	1955	1956	1957	1958	1959	1960	1961
<i>million dollars (1954 prices)</i>								
<i>Primary agriculture</i>								
1. Meat animals and products								
Output.....	337	355	58	†				
Trade*.....	- 248	- 287	- 732	- 833	- 867	- 909	- 949	- 1,227
2. Poultry and eggs								
Output.....	312	339	377	398	417	430	462	489
Trade.....	2							
3. Farm dairy products								
Output.....	343	378	402	402	389	402	393	414
Trade.....			- 56	- 74	- 86	- 76	- 149	- 320
4. Food and feed grains								
Output.....	108	133	217	235	240	240	240	240
Trade.....	- 25	- 80	- 18			- 9	- 18	- 82
5. Cotton								
Output.....	284	216	286	302	317	370	378	335
Trade.....	228	188	226	240	226	314	315	264
6. Vegetables								
Output.....	488	537	616	690	773	816	816	816
Trade.....	141	157	220	290	392	438	439	438
7. Fruits and nuts (excluding citrus)								
Output.....	340	374	374	321	285	272	258	244
Trade.....	50	57	47					
8. Citrus								
Output.....	137	151	151	212	215	215	219	219
Trade.....	109	120	118	180	185	185	189	189
9. Forage								
Output.....	181	199	126	109	105	107	106	127
Trade.....	- 2							
10. Miscellaneous agriculture								
Output.....	295	270	325	298	289	286	299	367
Trade.....	45	18	38	16	14	12		6
Water supply (1,000 acre-feet).....	23,640	22,200	22,200	20,980	20,532	20,785	22,200	22,200
Irrigated land (1,000 acres).....	7,048	6,512	6,591	6,349	6,231	6,276	6,356	6,288
Total harvested cropland (1,000 acres).....	12,547	11,677	10,907	10,328	10,027	9,973	9,895	10,032

\* Negative values of the trade variables signify imports; positive values, exports.

† Blanks indicate zero.

by primary agricultural sectors is presented in table 31.

With the exception of meat animals and products [UC 1], fruits and nuts (excluding citrus) [UC 7], and forage [UC 9], all primary agricultural sectors are growing. However, production of farm dairy products and food grains grow more slowly than domestic demand and, consequently, the corresponding imports increase.

The decline of production in the meat

animal sector is rather abrupt and tied closely to the reduction in forage production. A cursory inspection of the efficient water supply program reveals the reasons. The development of new water resources is too costly. In fact, even the operational costs of the medium-cost water supply sector are too high. It is, therefore, more efficient to divert resources to other activities and keep overall water deliveries stagnant. Because other water-using sectors keep

growing, the amount of water allocated to the production of forage is curtailed, and imports of meat and dairy products are expanded. This development is reflected in the use of irrigated land. In actuality, water supply was increasing throughout the period, thus supporting a stable output of forage. The meat animals and products sector was actually stagnant until 1959, growing faster thereafter.<sup>59</sup>

Another declining sector in the efficient program is "fruits and nuts." Apparently, this trend is caused by developments in labor constraints. As more and more workers are permitted to move into non-farm occupations, it is more efficient to cut back production in the fruits and nuts sector—a heavy labor user—and to employ the released workers in other sectors of the economy.

Two primary agricultural sectors with endogenously determined exports grow at a relatively high rate in the efficient program. These are the vegetables [UC 6] and the citrus [UC 8] sectors. But even the growth of these sectors tapers off toward the end of the planning period. Examining the efficient investment program, we find that the stunt growth of these sectors at the end of the period stems from the fact that their capital capacities have achieved the terminal values by 1958 (table 34). This is a clear end-of-period effect. In reality the output of vegetables exhibited wide fluctuations with a weak upward trend, and output of citrus actually declined. As already indicated, the decline in citrus production may be partly due to urbanization of citrus land, a process ignored altogether in the present model.

**Manufacturing sectors.** The efficient

program of production and trade by manufacturing sectors is outlined in table 32.

Apparently the food processing industries in California were sufficiently efficient to warrant a complete import substitution by these sectors. In reality this did not materialize, and levels of imported processed agricultural products were actually increasing. However, our formulation ignored some spatial factors of great importance in agricultural processing industries. Since it was assumed that agricultural products serving as inputs to the processing sectors may be imported, the efficient production program of the processing sector is based on imported raw material. For many of these products it is advantageous to process the product locally and then ship to California a less voluminous good. However, these are the kinds of relations which our model fails to capture.

The efficient levels of production and exports by the canning, preserving, and freezing sector reflect the efficient program for the primary agricultural sectors, and the decline in the production and exports of this sector is directly traceable to the decline of the fruits and nuts sector. In reality, exports declined only slightly in exports originating in the canning, preserving, and freezing sector.

The efficient production and trade schedule of chemicals and fertilizers [UC 16] is rather peculiar. For reasons which we do not understand, it is efficient to produce nothing in the first year (1955) and then to expand production to \$1,613,000,000 a year at which level it is maintained throughout the period.<sup>60</sup> This behavior points out, however, the economic desirability of a rapid develop-

<sup>59</sup> The surge in actual output after 1959 of "meat animals and products" is most likely due to important changes in the input mix and technology of meat cattle production, namely, large-scale and very efficient cattle feeding on feedlots. This, in effect, is an important structural change not accounted for in our model.

<sup>60</sup> The zero output in the first year looks more like a computational error, but our long search failed to detect any. Neither were we able to establish the reasons for this peculiar result.

TABLE 32  
EFFICIENT LEVELS OF OUTPUT AND TRADE BY MANUFACTURING  
SECTORS, CALIFORNIA, 1955-1961

UC sector	Base year, 1954 (actual)	1955	1956	1957	1958	1959	1960	1961
<i>million dollars (1954 prices)</i>								
11. Grain mill products								
Output.....	404	444	515	531	547	568	591	627
Trade.....	- 49	- 40	†					
12. Meat and poultry processing								
Output.....	1,026	1,129	1,428	1,514	1,578	1,658	1,740	1,784
Trade.....	- 209	- 137						- 39
13. Dairy products								
Output.....	571	628	754	794	794	794	909	936
Trade.....	- 105	- 77			- 32	- 69		- 15
14. Canning, preserving, and freezing								
Output.....	1,188	1,343	1,343	1,292	1,059	954	844	688
Trade.....	834	949	923	848	600	475	343	56
15. Miscellaneous agri- cultural processing								
Output.....	1,727	1,900	2,220	2,326	2,401	2,503	2,623	2,759
Trade.....	- 222	- 142						
16. Chemicals and fert- ilizers								
Output.....	565		1,613	1,613	1,613	1,613	1,613	1,613
Trade.....	- 559	-1,200	- 196	- 238	- 274	- 325	- 406	- 480
17. Petroleum								
Output.....	2,861	2,762	2,928	3,134	3,279	3,415	3,674	3,985
Trade.....	559	496	436	437	448	401	430	459
18. Fabricated metals and machinery								
Output.....	3,998	4,397	6,665	6,665	6,665	6,665	6,665	7,570
Trade.....	-3,028	-3,125	- 694	-1,031	-1,548	-2,120	-2,944	-4,599
19. Aircraft and parts								
Output.....	4,460	4,463	5,053	5,383	4,555	4,494	3,837	3,519
Trade.....	4,094	4,028	4,543	4,860	4,108	4,054	3,452	3,157
20. Primary metals								
Output.....	896	138	1,681	1,681	1,681	1,681	1,681	1,681
Trade.....	-1,016	-1,663	- 865	- 923	- 940	-1,000	-1,089	-1,349
21. Other manufacturing								
Output.....	4,645	5,071	5,071	4,865	4,495	4,099	3,541	3,204
Trade.....	-2,648	-2,441	-2,704	-3,370	-4,089	-4,932	-6,023	-7,148

\* Negative values of the trade variables signify imports; positive values, exports.

† Blanks indicate zero.

ment of the chemical industry. In fact, a shift in the expansion ray in favor of UC 16, say, would probably increase the rate of growth in the state's income and accumulated terminal stocks.

Another advantageous sector is the fabricated metals and machinery [UC 18] industry, as evidenced by the rapid growth of this sector's production in the efficient program. The actual development of UC 16 and UC 18 conformed to

the general principles manifested in the efficient program.

The efficient program of production and trade of primary metals [UC 20] resembles that of the chemicals and fertilizers sector and for the same reasons. In reality, however, this sector grew more slowly. Consequently, import substitution of primary metals also proceeded at a slower pace.

The efficient production schedule for

TABLE 33  
EFFICIENT LEVELS OF OUTPUT AND TRADE BY NONAGRICULTURAL  
AND NONMANUFACTURING SECTORS CALIFORNIA, 1955-1961

UC sector	Base year, 1954 (actual)	1955	1956	1957	1958	1959	1960	1961
<i>million dollars (1954 prices)</i>								
22. Mining								
Output.....	306	335	431	418	424	478	503	533
Trade.....	156	196	261	235	220	280	264	286
23. Utilities								
Output.....	1,589	1,748	1,944	2,068	2,128	2,245	2,335	2,440
Trade.....	— 98	‡						
24. Selected services								
Output.....	4,434	4,638	4,940	5,518	5,939	6,420	6,871	7,237
Trade.....	552	548	488	673	823	937	1,011	1,058
25. Trade and transportation								
Output.....	8,153	8,754	9,125	9,861	10,521	11,257	12,156	13,442
Trade.....	264	178	111	112	117	94	121	324
26. Unallocated services								
Output.....	10,213	10,764	11,532	12,485	13,128	14,261	15,039	15,955
Trade.....	120	258	16			227	123	288
27. Scrap and by-products								
Output.....	229	162	362	363	366	371	377	385
Trade.....	— 10							
28. Noncompetitive imports								
Output.....								
Trade.....	— 580	— 816	— 923	— 948	— 971	— 1,010	— 1,046	— 1,095
29-30. Construction								
Output.....	6,468	7,115	5,141	6,337	8,099	9,609	12,139	12,139
Trade.....								
31. State and local government								
Output.....	3,963	4,170	4,557	4,905	5,148	5,505	5,837	6,185
Trade.....								
32. Federal government								
Output.....	5,479	5,736	6,403	6,873	7,177	7,602	8,025	8,471
Trade.....								
37*. Direct household services								
Output.....	323	338	372	404	424	453	480	505
Trade.....								

† Negative values of the trade variables signify imports; positive values, exports.

‡ Blanks indicate zero.

the other manufacturing sector involves a rather steep decline with a concomitant rise in imports. In reality this drop in output did not materialize, though UC 21 was one of the laggard sectors.

The behavior of output and trade of UC 16, UC 18, UC 20, and UC 21 is consistent with our theoretical analysis of factors affecting the pattern of trade.<sup>61</sup>

The efficient levels of production and trade by the petroleum [UC 17] and

aircraft and parts [UC 19] industries are not controlled variables and are determined by levels of exogenous exports and domestic demand for products originating in these sectors.

**Nonagricultural-nonmanufacturing sectors.** The efficient program of production and trade by these sectors is listed in table 33. In spite of their economic importance, none of these variables is a control variable in the present

<sup>61</sup> See pages 11 and 45. The analysis presented there pertains to competitive behavior rather than to efficient programs. However, in view of the Pareto optimality of competitive equilibria, including equilibria in growth systems (Dorfman, *et al.*, 1958, pp. 318-22), the realization of our theoretical implication for a competitive system in efficient growth programs is not surprising.

formulation, and their values are determined by levels of the corresponding exogenous exports and domestic demand induced by the control variables.

Two points are worth noting: First, the upsurge of construction activity toward the end of the planning period. This phenomenon is related to the intense investment activity which accompanies the withdrawal of credit extended earlier to other states and the heavy borrowing taking place at the end of the period.

Second, the level of state and local government output (taxes) in the efficient program is lower throughout the planning period than the observed levels. As indicated on page 37, this is caused by the failure of our model to capture adequately the behavior of the state and local government sector. The diversion of fewer resources to public consumption might have also contributed to the higher rate of growth of the state's income in the efficient program.<sup>62</sup>

**The investment program.** The efficient program of net private investment is presented in table 34. Although it may appear somewhat erratic and hard to explain, it is, nonetheless, meaningful in several respects.

First, UC 26 stands out, which includes the "real estate and rental" subsector as a heavy user of new investment. Second to it is UC 25, "trade and transportation," which carries large inventories and employs large amounts of expensive transportation equipment. These two subsectors alone are respon-

sible for more than half of the new investment.

Second, a careful analysis of table 34 reveals that the various economic sectors may be classified into three principal categories: (1) growth leaders, (2) growth followers, and (3) laggards. The "growth leaders" comprise those sectors which, through rapid import substitution or export expansion, are growing at a high rate during the early stages of the program. The efficient investment program for these sectors involves heavy outlays in the early years of the planning period. Typically, the terminal capacity of these sectors is fully developed long before the planning horizon has been reached. The following sectors are identified as growth leaders in the efficient program:

- (a) Import substitutes—chemical and fertilizers [UC 16], fabricated metals and machinery [UC 18], and primary metals [UC 20].
- (b) Expanding exports—vegetables [UC 6], citrus [UC 8], and selected services [UC 24].<sup>63</sup>

The "growth followers" include sectors whose growth is derived from the general economic development. Most sectors producing nontradable outputs are included in this category. The investment program is characteristically spread over the entire planning period and increases at the same pace as the economy at large. This category represents a high proportion of the economic activity in the state.

The "laggards" include sectors pro-

<sup>62</sup> Lower government expenditures could enhance growth had the freed resources found employment in other sectors of the economy. However, high rates of unemployment prevailed during the second part of the planning period. It is, therefore, possible that lower government activity during these years would have depressed effective demand through a (negative) balanced budget multiplier and, in addition, would have deprived the state of certain investment in infrastructure and education.

<sup>63</sup> Export originating in UC 24 is determined exogenously and is not a control variable. Consequently, the efficient investment program for this sector is spread over the entire period. It cannot be denied, however, that the growth stimulus provided by the expanding export from UC 24 is of major importance.

TABLE 34  
EFFICIENT LEVELS OF NET INVESTMENT BY INVESTING  
SECTORS, CALIFORNIA, 1955-1961

UC sector	Base year, 1954†	1955	1956	1957	1958	1959	1960	1961
	million dollars (1954 prices)							
1.....	‡							294
2.....		22	14	12	14	15	18	42
3.....		33					18	317
4.....		19	5					142
5.....				6	85	3		17
6.....		33	31	35	18			
7.....						4	179	154
8.....			104	6		7		
9.....								183
10.....		1					43	191
11.....		14	3	3	4	5	7	16
12.....		64	18	14	17	17	9	
13.....		30	9			27	6	
14.....								278
15.....		169	55	39	53	63	72	101
16.....		300						
17.....				123	127	241	290	781
18.....		1,350					539	
19.....			100					
20.....		543						
21.....								1,792
22.....		48			40	22	26	70
23.....		691	434	213	414	317	370	2,163
24.....		353		233	265	249	202	753
25.....		284	1,328	1,191	1,329	1,623	2,321	3,319
26.....		2,635	1,152	2,104	3,702	4,965	7,204	5,076
27.....								
28.....								
29-30.....				185	284	476		
31.....								
32.....								
37*.....								
41.....								
42.....								
43.....								
51.....								
Total.....	6,002	6,889	3,253	4,164	6,352	8,034	11,304	15,639

† Estimates of base year investment by individual sectors were not computed.

‡ Blanks indicate zero.

ducing tradable outputs under conditions of a deteriorating comparative advantage. Consequently, the efficient program for these sectors consists of shrinking exports and expanding imports. Typically, investment in these sectors is postponed to the end of the planning period. The following sectors are laggards in the present analysis:

- (a) Import substitutes—meat animals and products [UC 1], farm dairy

products [UC 3], food and feed grains [UC 4], forage [UC 9], and other manufacturing [UC 21].

- (b) Exports—fruits and nuts [UC 7]; canning, preserving, and freezing [UC 14]; and aircraft and parts [UC 19].<sup>64</sup>

This classification of sectors brings into sharp focus the relations between the pattern of trade and induced investment. The potential for regional growth

<sup>64</sup> The inclusion of "aircraft and parts" among the "laggards" follows the same reasoning that led to the inclusion of UC 24 among "growth leaders."

is thus linked to the possibilities for export expansion and import substitution.<sup>65</sup>

Table 34 also reflects two types of effects characteristic of our formulation. These are the "beginning of period" effect and the "end of period" effect. Since the annual rate of investment is restricted in the efficient program only by the availability of investment funds and since domestic saving, unilateral transfer, and the possibility of borrowing provide the investment funds in great quantities, capital capacities may be expanded rapidly. Apparently, the initial configuration of capital capacities was not optimal, and all capital resources available in the first year were mobilized by the efficient program for the purpose of investment in domestic productive capacity. Having readjusted capital capacities, the efficient program proceeds by allocating the reduced amount of capital resources to domestic investment. However, as the planning horizon is approached, the direction of capital flow is reversed. The end-of-period effect then comes into action.

Because the total amount of terminal capital stocks on the expansion ray constitutes the optimization criterion, the last years of the planning period are marked by a frenzy investment in domestic productive capacity, particularly in the laggard sectors. Borrowing is also pushed to the limit. To the extent that the planning period is extended and the horizon becomes more distant, the end-of-period effect is also postponed.

The present formulation is thus instru-

mental in identifying sectors whose growth should be promoted at the early stages of a planned development effort. It is also suggestive as to possible modifications in the expansion ray for terminal capital capacities. Thus, if the expansion ray is shifted in the direction of growth leaders and away from laggard sectors, growth within the planning period may be accelerated. Whether the resulting configuration of terminal capital capacities is regarded desirable is another question that must be considered with reference to the postplanning period possibilities.

Another important characteristic of efficient programs is relevant in the present context: the tendency of production to concentrate in fewer activities as the accumulation of capital progresses (but before the end-of-period effect becomes appreciable). However, this behavior occurs in systems where the number of positive endogenous trade activities is greater than the number of *effective* primary resource constraints plus one.<sup>66</sup> In other words, given sufficient time, the number of sectors which are actively involved, both in endogenous trade and production simultaneously, will become equal to the number of *effective* primary resource constraints plus one.<sup>67</sup> Unless the number of primary resource constraints is sufficiently large, efficient programs will tend, over time, to concentrate production and investment in certain sectors of the economy. This tendency is reversed as the planning horizon is approached. Table 34 shows this effect.

<sup>65</sup> The subject has been analyzed in a more aggregative fashion by Hartman and Seckler (1967).

<sup>66</sup> A constraint is effective if it is associated with a positive shadow price.

<sup>67</sup> The reason for this behavior is related to the form of the efficiency set  $E_t(K_1, D_0^c)(t = 1, 2, \dots, T)$  (for simplicity we consider only foreign state credit).  $E_t(K_1, D_0^c)$  is a piecewise linear manifold in the capacities and state foreign credit space. It may be represented by a concave function  $k_{1t} = F_t(k_{2t}, \dots, k_{nt}, D_0^{c-1})$ . As time passes,  $E_t(K_1, D_0^c)$  moves in a northeastern direction; and, furthermore,  $F_t$  becomes progressively less concave—that is, the substitutability of capital capacities increases. Suppose, now, that for given time,  $t$ , we know the optimal shadow prices of all control variables and the optimal values of all investment variables and  $D_0^c$ . Denote by  $\bar{X}_t$  the outputs used for investment and exogenous exports in  $t$  and by  $\bar{D}_t^c$  the optimal value

## The dual solution

The dual solution of our linear programming problem consists of the valuation of the scarce resources, restricting the amount of accumulated capital along the expansion ray of terminal capital capacities. The solution values represent an internal pricing of the various resources in terms of the objective function and may be construed as the marginal value productivities. We shall refer to these values by the term *shadow prices*. There is an obvious interest in the shadow prices as indicators of resource values. Shadow prices of the various resources in different years are listed in table 35.

**Transferred capital.** This shadow price is associated with the balance-of-payment constraint and reflects the marginal contribution of unilateral transfers to the objective function. Transferred capital may also serve conveniently as a numeraire. That is, at any point in time we may want to express price relationship in terms of current dollars and

not in terms of the objective function.<sup>68</sup> The relations among shadow prices of transferred capital in different years can be derived with the aid of table 25.<sup>69</sup> Thus, if we denote the shadow price of transferred capital by  $p_t^D$  and the shadow prices of the various goods by a vector  $p_t$ , we derive from columns corresponding to  $D_t^c$  and  $D_t^d$  (disregarding  $\epsilon$ ) in table 25 the relation:

$$p_{t-1}^D = (1 + r)p_t^D - rp_t^C. \quad (31)$$

Dividing through by  $p_t^D$  and rearranging, we find the "marginal rate of substitution" between a dollar transferred in  $t$  and a dollar transferred at  $t + 1$  to be:

$$\begin{aligned} \frac{p_{t-1}^D}{p_t^D} &= 1 + r \left( 1 - \frac{p_t^C}{p_t^D} \right) \\ &= 1 + r\bar{s}_t \end{aligned} \quad (32)$$

where  $\bar{s}_t = 1 - p_t^C/p_t^D$  may be regarded as a marginal saving rate in year  $t$

of  $D_t^c$ . To find the optimizing values of the capital capacities  $K_t$ , the state foreign credit  $D_{t-1}^c$ , the outputs  $X_t$ , and the endogenous trade variables,  $M_{ct}$  and  $E_t$ , we have to solve the following *single-period* programming problem:

$$\text{Max } \Pi = v(X_t, M_{ct}, E_t, K_t, D_{t-1}^c)$$

subject to:

- (i)  $TX_t + M_{ct} - E_t \geq \bar{X}_t$
- (ii)  $RX_t \leq Z_t$
- (iii)  $LX_t - K_t \leq 0$
- (iv)  $k_{1t} - F_t(k_{2t}, \dots, k_{nt}, D_{t-1}^c) = 0$
- (v)  $D_{t-1}^c + V'E_t - V'M_{ct} = \bar{D}_t^c$
- (vi)  $X_t, M_{ct}, E_t, K_t, D_{t-1}^c \geq 0$

where  $v(X_t, M_{ct}, E_t, K_t, D_{t-1}^c)$  is a linear function depending on the shadow prices. For sufficiently large  $t$ , (iv) may be approximated by a hyperplane in a large enough neighborhood of the solution. That is, in the long run (iv) may be conceived as a *single* overall capital constraint. Ordinarily, (iv) is an effective constraint. By a well-known theorem, the number of positive real activities in the solution cannot exceed the number of effective constraints. Now, since  $L$  is positive and diagonal, then to every effective constraint in (iii) with positive  $x_{it}$ , there corresponds a positive  $k_{it}$ ; and if  $k_{it}$  is zero, then  $x_{it}$  is also zero. Also, if (v) is effective, then  $D_{t-1}^c$  is in the basis. Hence,



TABLE 35

SHADOW PRICES OF TRANSFERRED CAPITAL, PRIMARY  
RESOURCES, AND CAPITAL CAPACITIES BY UC SECTORS CALIFORNIA,  
1955-1961

Restriction	Resource unit	1955	1956	1957	1958	1959	1960	1961
		<i>1,000 dollars per resource unit</i>						
<i>Transferred capital</i>	1,000 dollars	1.07878	1.07023	1.06243	1.05503	1.04783	1.04026	1.03281
<i>Primary resources</i>								
Total cropland.....	acre	*						
Irrigable land.....	acre							
Water potential, UC 41.....	acre-foot	.00064	.00122				.00086	.00151
Water potential, UC 42.....	acre-foot							
Water potential, UC 43.....	acre-foot							
Civilian labor force.....	employee		.24856	.38563	.42232	.40639	.43090	.34955
Nonagricultural labor force.....	employee		.61122	.49618	.43229	.45040	.50885	.60496
<i>Capital capacities by UC sector</i>	1,000 dollars							
1.....								
2.....			.00432	.00180	.00443	.00694	.00542	.00585
3.....		.00812	.01427	.00439		.00242		.00512
4.....			.00237	.00876	.00586	.01419	.00522	.00039
5.....					.00219	.00648	.01926	
6.....		.12512	.01290	.00575	.00389	.06673	.07151	.09467
7.....			.01640	.00731				
8.....		.02466	.02667	.01114	.00472	.00543	.00512	.01166
9.....		.00121						
10.....			.03228					.00729
11.....		.05892	.00611	.00475	.00750	.00612	.00615	.00622
12.....		.06169	.00755	.00422	.00705	.00731	.00664	.06301
13.....		.04721	.00090	.00623	.00548	.00631	.00567	.00936
14.....		.01976	.01286					
15.....		.01868	.00772	.00487	.00533	.00713	.00661	.00596
16.....			.03575	.02243	.02472	.02381	.02696	.02685
17.....					.00411	.00684	.00514	.00442
18.....		.03202	.01020	.00236	.00396	.00486	.00587	.00670
19.....				1.09080				
20.....			.01683	.00977	.01304	.01307	.01321	.01380
21.....		.02778	.01117					
22.....			.05051			.00683	.00667	.00604
23.....		.53749	.00026	.00492	.00493	.00756	.00537	.00518
24.....				.00379	.00501	.00737	.00325	.00317
25.....			.00296	.00107	.00977	.00742	.00597	.00568
26.....				.00235	.00488	.00688		
29-30.....		.10600			.00473	.00789	.05608	.09921
42.....								
43.....								
51.....								

\* Blanks indicate zero.

the number of positive production and endogenous trade activities cannot exceed the number of effective constraints in (i), (ii), and (iv).

Let  $m$  be the number of effective constraints in (ii), and suppose that there are  $q$  ( $q \leq n$ ) positive trade activities in the solution. Then, the number of positive production activities cannot exceed  $n + m + 1 - q < n$  where  $n$  is the dimension of  $T$ . Since  $T^{-1} >> 0$  and  $\bar{X}_i > 0$ , then, for every commodity which is not traded, there must be a positive production activity. So, there are  $n - q$  production activities in sectors without trade. Hence, there are at most  $(n + m + 1 - q) - (n - q) = m + 1$  commodities which are produced and traded simultaneously.

<sup>68</sup> The choice of numeraire is entirely arbitrary. We could thus express value in terms of "wage units"—that is, select labor as numeraire. Imported capital appeared to be a more natural choice as it measures value in familiar terms. Also, "current dollars" does not imply, in this case, a departure from our basic 1954 price level.

<sup>69</sup> Here we employ some basic relations among dual variables; see, for instance, Dorfman, *et al.*, (1958, pp. 100-04). For every year constraints, equation (25), involve the sign  $\geq$ . To reverse the direction of inequality, we multiply equation (25) by  $-1$ .

TABLE 36  
SHADOW RENTS OF WATER RESOURCES AND LABOR WAGES IN TERMS  
OF CURRENT INCOME CALIFORNIA, 1955-1961

Resource	Unit	1955*	1956	1957	1958	1959	1960	1961
		1,000 dollars per resource unit						
Water.....	acre-foot	.00468	.0090				.0072	.0128
Agricultural labor.....	employee	†	1.8316	3.1156	3.5965	3.5540	3.5864	2.9559
Nonagricultural labor.....	employee		6.3357	7.1254	7.2779	7.4948	7.8215	8.0715

\* Values for 1955 were computed on the assumption that  $\bar{s}_{1955} = \bar{s}_{1956}$ .

† Blanks indicate zero.

Source: Computed from table 35.

$$(p'_i C / p^D_i \text{ is the value of consumption per unit income normalized in terms of current dollars.}) + b_j p_{jt} \quad (33)$$

$$+ \sum_k r_{kj} v_{jt}$$

Equation (32) states the fact that a dollar transferred in year  $t - 1$  will yield an income of  $r$  dollars out of which  $r\bar{s}_t$  will be saved so that after one year the single dollar will grow to  $1 + r\bar{s}_t$  dollars.  $r\bar{s}_t$  thus represents the *own rate of interest* (after accounting for consumption) of transferred capital in the efficient program.

Equation (32) allows us to estimate the marginal saving in every year from the figures in table 35. Using the value  $r = .063$ , the estimates of  $\bar{s}_t$  vary between  $\bar{s}_{1959} = .1091$  and  $\bar{s}_{1956} = .1268$ . Own rates of interest thus varied between .00687 and .00799.<sup>70</sup>

**Primary resources.** The figures in table 35 represent rents on land and water resources as well as labor wages. These figures are in terms of the objective function and not in terms of current income. The following analysis will yield estimates of rents and wages in terms of currently transferred dollars. From the columns corresponding to  $X_t$  in table 25, we get for the  $j$ th productive activity:

$$p_{jt} - \sum_i a_{ij} p_{it} = u_j \sum_i p_{it} c_i$$

where

$p_{jt}$  = the shadow price of the  $j$ th commodity in year  $t$

$c_i$  = the  $i$ th element of  $C$

$b_j$  = the  $j$ th diagonal element in  $L$  (capital/output ratio in sector  $j$ )

$r_{kj}$  = an element of  $R$

$p_{jt}$  = corresponding rents of capital capacities

and

$v_{jt}$  = corresponding rents (wages) of primary resources.

The first term on the right of equation (33) represents the "consumption cost" associated with a unit level of output  $j$ , while the other two terms on the right of equation (33) represent incomes saved. Hence, in order to express rents and wages in terms of current income, we have to divide the cited rents and wages by  $p^D_t \bar{s}_t$ . The computed values of the rents on water resources and of labor wages, in terms of current income, are given in table 36.

Examining tables 35 and 36, we first notice that of all land and water resources only the water supply potential

<sup>70</sup> The low values of the own rates of interest are due to the fact that a major share of the returns on capital is continuously being consumed.

of the low-cost water sector had a positive value, and in some years even this shadow price was zero.

Shadow wages in terms of current income are rising for all types of labor.<sup>71</sup> In the first year, shadow wages are zero. Apparently, some capacity constraints are sufficiently tight to render the labor constraint ineffective. However, investment in the first year removes these bottlenecks and the labor constraint comes into effect.

Shadow wages appear to be higher than the prevailing wages during the period 1955–1961. This may be due to the omission of some effective constraints.

**Capital capacities.** The shadow prices of capital capacities given in table 35 are the rents,  $p_{it}$ , expressed in terms of the objective function. These rents can also be expressed in terms of current income in much the same way as the wages were expressed. A rough and ready idea

on the values of capacity rents in terms of current income can be obtained by multiplying by 8 the corresponding figure in table 35. The values obtained are of the order of magnitude of 2–10 per cent.

The beginning-of-period effect is manifested in the capital rents also. Notice that in 1955 there are relatively many sectors with idle capacity and zero shadow rent. Furthermore, for some sectors, such as UC 6, UC 23, and UC 29–30, the shadow rents are very high. The productive capacities of these sectors are the main bottlenecks in the development process. As the investment program proceeds, bottlenecks are removed, idle capacity is diminished, and the rent structure becomes more uniform.

The shadow rents of the medium- and high-cost water supply capacities and irrigated land are zero throughout the period. There is, therefore, no incentive to invest in these sectors.

## Conclusion

### The role of resource expansion and technical progress as determinants of economic development

Growing supplies of productive resources play a dual role in the economic evolution. First, the mere increase in the amount of employed resources brings about a rise in aggregate output and income; and, second, to the extent that resource expansion is not equiproportional, it is conducive to changes in resource allocation by generating shifts in the economy's output mix and pattern of trade.

The NSP grew at an annual rate of 6.1 per cent. This growth was generated by an annual increase of 6.5 per cent in

capital stocks and 3.2 per cent in employment.

This is a remarkably fast rate of increase in the state's resource endowment. Our analysis of the von Neumann path suggests that internal saving alone could not sustain a rate of capital accumulation exceeding 3.5 per cent. The observed higher rate was, therefore, supported by the transfer of capital into the state. The rapid increase in employment is also, in part, due to immigration. Immigration thus furnished the state's economy with both capital funds and the labor force required to support its accelerated growth.

In terms of physical units, the capital/

<sup>71</sup> Shadow wage of nonagricultural labor in terms of current income was obtained by dividing the sum of the shadow prices of "civilian labor force" and "nonagricultural labor force" by  $p_{1955}$ . The sum of the two was used, since an additional nonagricultural worker in the economy adds one unit to both restrictions.

labor ratio increased rapidly. However, when measured in efficiency units, labor grew at the rate of 5.7 per cent so that capital had been accumulating only slightly faster than labor (as measured in efficiency units).<sup>72</sup> On the basis of a trade theoretic analysis of the Heckscher-Ohlin variety in which capital mobility is assumed away, one would predict a slow shift to capital-intensive industries. In the present framework, however, enhanced lending is predicted instead, the observed shift to capital-intensive industries being ascribed to the effects of the flow input augmenting technical change.

An economically significant feature is the observed lower rate of technical progress in the "services" sectors. Because some of these sectors are rather large and capital intensive, they tend to exert a dampening influence on the pace of economic growth. This tendency is expected to become more pronounced in the future.

Economies of scale also seem to have played an important role in the development of the California economy. However, it is rather difficult to assess these effects because they were confounded with the shift toward capital-intensive industries induced by the flow input augmenting technical change.

Spatial relationships, although not explicitly recognized in our model, must have also influenced the pattern of production and trade. In particular, the efficient program (pages 58 ff.) suggests that primary agricultural products would have been imported and processed within California were it not for the lower cost of transporting processed products. A similar relationship apparently influenced the development and trade in primary metals.

Demand and supply of resources in

agriculture were clearly out of balance throughout the analyzed period; that is, a surplus labor force was engaged in primary agricultural production. The disequilibrium is evidenced by the lower wages paid to farm workers and by the continuous decline in agricultural employment. The disequilibrating forces must have been at work even before 1954, and they continued to operate through 1963. Essentially, these forces consisted of high rates of technical progress in agriculture, coupled with low income and price elasticities of demand for farm products. Migration of labor out of agriculture apparently did not proceed fast enough to reinstate equilibrium conditions. Such developments are known to have characterized the United States agriculture in general.

The development of water resources in California had only limited effects on the state of the agricultural sectors. Furthermore, as the efficient program suggests, it probably proceeded beyond the optimal level.

### **The role of demand factors as determinants of economic development**

In considering the role of demand behavior in determining the nature of the development process, several classes of final demand factors must be distinguished. These include three kinds of domestic demand—household, investment, and public—and the external demand for export.

Because the aggregate consumption function is more or less homogeneous, private consumption grew at the same rate as income—6.2 per cent, annually. However, demand for individual outputs was not uniform. The income elasticities of demand for primary and processed agricultural products were

<sup>72</sup> When measured in efficiency units, the rate of change in employment consists of the rate of change in the number of employees plus the rate of labor-augmenting technological progress.

much lower than unity.<sup>73</sup> The income elasticities of demand for other manufacturing sectors were, on the average, slightly higher than unity. The highest elasticities were estimated for utilities and various services, including real estate and rentals. Income elasticities of demand for the outputs of these sectors are estimated at the range of 1.0 to 1.9. As per-capita income increased, household demand shifted away (in relative terms) from agricultural commodities to manufactured commodities and, even more so, to services. Such behavior yields several interesting effects. First, the services sectors and, in particular, the real estate and rental subsector are highly capital intensive and, essentially, nontradable. Consequently, domestic demand for capital relative to labor is increasing, thus lowering the capital/labor ratio in the tradable sectors and encouraging borrowing. This tendency offsets the effects of capital accumulating faster than the growth of labor. Also, the share of investment in the GSP, for a given rate of economic growth, must increase. Second, economic growth will tend to slow down since (a) income generated per unit capital capacity is diminishing and (b) rates of technical progress in the services sectors are relatively low.

The level of private domestic investment is closely related to the overall rate of economic growth. The higher the rate of growth, the greater is the investment activity and the higher the demand for capital goods. Thus, the actual output of the construction sector in 1954 was about 50 per cent greater than the output of this sector under von Neumann maximal proportional growth conditions without capital import. A similar relation held true for the fabricated metals and machinery sector, although here a portion of the demand was met by imports. Again, since construction is a

nontradable sector, high rates of growth lead to increased imports of tradable goods.

Another important demand factor is the high rate of growth in "government purchase of goods and services"—7.3 per cent, annually. Evidently, the income elasticity of public expenditures is greater than unity. Again, this is a nontradable output.

Two important trends in the exogenous demand for the state's exports ought to be mentioned. Most important is the decline of about \$1 billion in the export of aircraft and parts. At the same time exports of selected services grew by some \$500 million. As suggested by our characterization of the California economy, the state's rate of growth depends in a crucial way on developments in its export markets. Hence, the slowdown of demand for aircraft and parts must have had deleterious effects on the rate of growth of the state's economy and must have created adjustment problems.

In view of the foregoing analysis, demand factors appear to have been dominant in determining California output mix and the occupational composition of its labor force. The relatively rapid rise of demand for nontradable and exogenously determined exports of services, the high rate of economic growth, and the rapid increase in public expenditure tended to shift labor and capital resources toward the services sectors—construction and government—and away from the production of tradable commodities.

### Did the California economy grow efficiently?

Taking the efficient program (pages 58 ff.) as a norm of comparison, the efficient annual growth rate of the state's income amounted to 6.6 per cent as compared to the actual rate of 6.2 per cent.

<sup>73</sup> The income elasticities mentioned hereafter refer to per-capita consumption functions.

In view of all effective restrictions which existed in the real world but not recognized in the analysis, the divergence between the efficient and actual growth rates is strikingly small. Furthermore, the production, trade, and investment programs associated with the actual and efficient growth paths, respectively, differ in many ways. Apparently, the economy's growth rate is not very sensitive to the corresponding differences in resource allocation. In fact, it is entirely possible that a major portion of the discrepancy between the efficient and actual growth rates is attributable to the levels of unemployment—3.5 per cent in the efficient program versus an average of 5.2 per cent in actuality.

### Implications for economic forecasting

Lee (1967, p. 1) asserted that "Realistic forecasts . . . require the imposition of realistic conditions and constraints, and the development of such conditions itself would present a substantial forecasting problem." He was referring, no doubt, to the fact that, given California's input-output relations (that is, the flow, stock, and primary resource coefficients) and the income-consumption relations, an economic forecast would still have to rely on a California projected pattern of external trade.

The findings of the present study shed light on the principal interactions between growth and trade phenomena and thus provide some basis for a more comprehensive economic forecast. In other words, our analysis suggests certain guidelines for treating the pattern of trade as an endogenous relation. Admit-

tedly, the forecast still depends on a number of exogenously given projections, yet this dependence is narrowed down considerably.

Any forecasting scheme will have to begin with population projections. This applies to natural population growth as well as to immigration. To our knowledge, the mutual relationship between economic activity and immigration has not yet been established, and immigration projections must be developed independently. Such projection may also serve in forecasting capital transfers into the state and the future growth of labor force. If past experience is any indication, the anticipated annual rate of change in the domestic state income is about equal to the rate of growth of employment plus 3 per cent.<sup>74</sup> Similarly, the rate of capital accumulation is about equal to 3.5 per cent annually, which is the maximal rate of capital accumulation along the von Neumann path plus capital imports. The initial forecasts thus obtained allow one to predict household consumption and public expenditures.<sup>75</sup>

The pattern of trade may be developed through a sequence of revised approximations. An initial approximation of California pattern of trade is obtainable by developing projections of exogenous exports and extrapolating current trends in the endogenous trade variables.<sup>76</sup> It is advisable at this stage to impose a "balance of payment" constraint on the trade projections; that is, the deficit on current accounts should be made equal to the anticipated unilateral capital transfer. Given the forecast of final demand for household consumption, public expenditures, and external trade, the

<sup>74</sup> The added 3 per cent consists of (a) the combined rates of labor and flow inputs augmenting technological progress and (b) a "redistribution of labor" effect; see table 17 and preceding text.

<sup>75</sup> Our estimated "consumption (tax) function" for "state and local government" erred on the lower side in predicting public expenditures. Evidently, the income elasticity of this variable is greater than the assumed unity.

<sup>76</sup> Exports regarded in the present study as exogenously given are listed on page 65. The list may, of course, be modified.

system can be solved to yield the corresponding investment and production program (For the solution procedure see Lee (1967, Appendix A). Resource availability and requirements may then be checked and the pattern of trade revised to insure the balancing of the two. Our theoretical discussion and empirical findings, concerning the effects of factor proportions in the residual resource endowment and the nature of technological progress on trade behavior and inter-regional capital movements, should facilitate and guide the revisions in the pattern of trade.

In its present structure, the linear programming formulation is practically useless as a forecasting device. However, by imposing certain supplementary constraints on the trade variables, it may be transformed into a useful prediction technique.

### **A critical review of assumptions and methods**

As it often happens in comprehensive and detailed empirical studies, there was no way to escape the need to adopt some simplifying and rather bold assumptions. The crucial assumption, it would seem, is the one denying the existence of capital-augmenting technical progress. If capital coefficients were to decline at an annual rate of, say, 2–3 per cent, then the observed rate of growth could have been attained without reliance on imported capital. In this case California would have accumulated an enormous amount of foreign assets—that is, provided our estimates of unilateral transfers are not badly biased upward. The characterization of the capital accumulation process, as well as the efficient growth program in its present formulation, would thereby become totally irrelevant.

Lacking empirical evidence, it is not easy to judge the validity of this assump-

tion. Nevertheless, even if one is willing to admit in principle capital-augmenting technical progress, it would have to be asserted somewhat along a “vintage model” approach that such a change applies to new investment only. The damage entailed by an incorrect assumption is thereby considerably diminished.

Another dubious assumption concerns the linearity of our model. Linear consumption and production relations are acceptable as approximations only if one considers small changes in the variables. Because our analysis spans a somewhat longer period with substantial variation in several important variables, the linearity assumption may prove invalid. This weakness marred the part of the analysis dealing with the behavior of public expenditures over time. Possible effects of economies of large-scale production were also overlooked.

The assumption of constant relative prices is no doubt incorrect. Given the degree of disaggregation of the present model, price variation could not be dismissed as unimportant. In particular, behavioral relations, such as demand for individual products, cannot always be regarded as price inelastic. In these cases, significant price effects in demand behavior might have been overlooked. Furthermore, where price variations are appreciable, some of the definitional relations stated in our model, such as the balance-of-payment identity, are not satisfied. Again, we were unable to appraise the error introduced because of the price-constancy assumption.

An attempt was made to characterize the process of capital formation under trade by determining the von Neumann path of maximal proportional growth. The characterization abstracts from the role of primary resources, such as labor, land, and water as well as capital imports as determinants of growth and trade. For California’s economy, this ab-

straction is unrealistic. Yet, given the rate of growth of labor (measured in efficiency units) and the rate of land and water augmenting technical change, one might be inclined to accept the "restricted trade" solution as a fairly realistic characterization. However, the sizable import of capital is still not accommodated for. As things stand, the characterization applies to a hypothetical rather than an actual situation. As such, it is a useful device in evaluating the role of capital transfer.

Certain serious difficulties are inherent in the dynamic linear programming formulation of the efficiency problem. First, the number of primary resource restrictions is too small, with the resulting tendency of the solution to concentrate production in few sectors of the economy. This weakness was partly obviated by adding direct output restrictions—an obviously arbitrary procedure. Second, the programming period was much too short so that end-of-period effects obscured some important features of long-run optimal growth. Unfortunately, these two shortcomings can be overcome only in a restricted number of ways—namely, adding more constraints to re-

flect the various limiting relationships. In particular, one could restrict the rate of growth of individual sectors by imposing "recursive programming" type constraints. In addition, the planning period could be lengthened. However, such extensions of the model may render the programming problem prohibitively large.

### Concluding remarks

This critical review of some of the crucial assumptions and analytic methods employed in the present analysis is not exhaustive; many important weaknesses were left unmentioned, as for example, the accuracy and reliability of the data used in the analysis. On the whole, however, it is hoped that the present study succeeded in tracing out the principal forces determining the pattern of trade and growth of the California economy during the decade 1954-1963. Many of the structural relations established in the present analysis, as well as some of the theoretical constructs, are, hopefully, of a more permanent nature, and their importance should transcend the historical economic episodes of the analyzed period.



## Appendix A

### Computation of von Neumann's Growth Path and Supporting Prices

Presented here is an algorithm for computing von Neumann's growth rate,  $\alpha^* = \lambda^* - 1$ ; von Neumann's normalized output vector,  $W^*$ ; and von Neumann's normalized price vector,  $P^*$ , for the expanding economy described. The corresponding stocks vector,  $F^*$ , is easily computed from the output vector. The proposed algorithm is an adaptation of a more general algorithm developed by Weil (1964) to our particular formulation.

In terms of the notation adopted in this monograph, the desired solution is a set— $\alpha^*$ ,  $W^*$ , and  $P^*$ —which satisfies (Hamburger, *et al.*, 1967).

$$\hat{T}W^* \geq \alpha^* \hat{B}W^* \quad (\text{A-1})$$

$$P^* \hat{T} \leq \alpha^* P^* \hat{B} \quad (\text{A-2})$$

$$P^* \hat{T}W^* > 0. \quad (\text{A-3})$$

Notice that analogous conditions hold for any transformation set  $S_\sigma(\sigma \in \Sigma)$ .

The proposed algorithm consists of the following steps:<sup>77</sup>

- (a) Select an initial producible set of activities  $(\hat{T}_1, \hat{B}_1)$ .
- (b) Calculate:

$$Q_1 = \hat{T}_1^{-1} \hat{B}_1.$$

- (c) Calculate approximate values of:

$$\mu_1^* = \lim_{t \rightarrow \infty} \frac{|Q_1^{t+1} \bar{W}|}{|Q_1^t \bar{W}|}$$

$$\hat{W}_1^* = \lim_{t \rightarrow \infty} \frac{Q_1^t \bar{W}}{|Q_1^t \bar{W}|}$$

and

$$p_1^* = \lim_{t \rightarrow \infty} \frac{\bar{W}' Q_1^t}{|\bar{W}' Q_1^t|}$$

$$\alpha_1^* = \frac{1}{\mu_1^*}$$

where  $\bar{W}$  is a positive arbitrary vector and the symbol  $|X|$  denotes the norm of the vector  $X$  (Tsukui, 1968). By virtue of properties (c) and (d) on page 00, von Neumann Path of Maximal Growth,  $Q_\sigma > 0$  for  $\sigma \in \Sigma$ ; and, therefore,  $\mu_1^*$  is the Forbenius root of  $Q_1$ , and  $\hat{W}_1^*$  and  $P^*$  are the associated eigenvectors. Computations are carried out up to a finite  $t$  depending on the required level of accuracy.<sup>78</sup>

(d) Calculate:

$$G_1 = P_1^*(\hat{T}_1 - \alpha_1^* \hat{B}_1).$$

Then, select an activity that was excluded from  $(\hat{T}_1, \hat{B}_1)$  for which the element  $g_{1i}$  of  $G_1$  is positive and largest among all elements of  $G_1$ . Substitute this activity into the producible selection  $(\hat{T}_1, \hat{B}_1)$  in place of an activity producing or importing the same commodity. A new producible selection  $(\hat{T}_2, \hat{B}_2)$  is thereby formed.

(e) Repeat (b), (c), and (d) until  $G_\sigma \leq 0$ .

It remains to demonstrate that a von Neumann solution has been attained at the termination of the computational procedure and that the procedure is convergent.

Let us first demonstrate the attainment of a solution. To this end, let  $\bar{\sigma}$

<sup>77</sup> A computer program employing the proposed algorithm was written by Peter Garrod for the IBM 1130. This program was used in obtaining the numerical solution presented on page 54.

<sup>78</sup> In the present analysis,  $t = 9$  was associated with an accuracy of about  $\pm 10^{-7}$ .

denote the final step; that is,  $G_{\sigma}^{-} \leq 0$  for the first time. Then, since  $\hat{W}_{\sigma}^*$  is the eigenvector of  $Q_{\sigma}$  associated with  $\mu_{\sigma}^*$ ,

$$(Q_{\sigma}^{-} - \mu_{\sigma}^* I) \hat{W}_{\sigma}^* = 0;$$

and, therefore,

$$(\hat{T}_{\sigma}^{-} - \alpha_{\sigma}^* \hat{B}_{\sigma}^{-}) \hat{W}_{\sigma}^* = 0.$$

Now form  $W_{\sigma}^*$  by equating its  $i$ -element,  $w_{\sigma,i}^*$ , to the corresponding element in  $\hat{W}_{\sigma}^*$  if the  $i$ th activity is in the producible solution  $\bar{\sigma}$ ; otherwise, set  $w_{\sigma,i}^* = 0$ . It follows that  $W_{\sigma}^*$  satisfies equation (A-1).

Also, since  $G_{\sigma}^{-} \leq 0$ , equation (A-2) is satisfied. Since equation (A-3) is satisfied for all  $\sigma$ ,  $\alpha_{\sigma}^*$ ,  $W_{\sigma}^*$ , and  $P_{\sigma}^*$  form the desired solution.

At this point, we comment that, by virtue of  $\hat{T}_{\sigma}^{-1}$  being strictly positive for all  $\sigma \in \Sigma$  [property (c) on page 51],  $P_{\sigma}^*$  and  $\hat{W}_{\sigma}^*$  are also strictly positive for all  $\sigma \in \Sigma$  (Karlin, 1962). It, therefore, follows that  $W^*$  is an extreme point in  $E^{(N_X + N_M + N_E)}$ ; that is, it has  $N_X + 1$  positive elements with all other elements being equal to zero.

We shall now demonstrate the convergence of the computational procedure. In doing so, we shall make use of the following properties of the model formulated on page, 50 ff., which is a special variety of the generalized von Neumann model of an expanding economy. (For details, see Hamburger, *et al.*, 1967).

Define:

$$M_{\sigma}(\alpha) = \hat{T}_{\sigma} - \alpha \hat{B}_{\sigma}$$

and let  $v_{\sigma}(\alpha)$  be the value of the zero sum game with the payoff matrix  $M_{\sigma}(\alpha)$ . Then,

$$(i) v_{\sigma}(\alpha) = \min_P \max_{\hat{W}} P M_{\sigma}(\alpha) \hat{W}$$

$$(ii) v_{\sigma}(\alpha) = \text{continuous and strictly decreasing in } \alpha.$$

(iii) Given any producible selection  $(\hat{T}_{\sigma}, \hat{B}_{\sigma})$ , the von Neumann solution relative to the transformation set  $S_{\sigma}$  is obtained when

$$v_{\sigma}(\alpha) = v_{\sigma}(\alpha_{\sigma}^*)$$

$$= 0;$$

and the associated values of  $\alpha_{\sigma}^*$ ,  $\hat{W}_{\sigma}^*$ , and  $P_{\sigma}^*$  are those obtained by steps (b) and (c) of the proposed algorithm.

The last part of (iii) is demonstrable in the same way as the attainment of  $W^*$  was shown.

(iv)  $M_{\sigma}(\alpha_{\sigma}^*) = \hat{T}_{\sigma} - \alpha_{\sigma}^* \hat{B}_{\sigma}$  has only  $n - 1$  independent columns. This is because  $M_{\sigma}(\alpha_{\sigma}^*) W_{\sigma}^* = 0$  for  $\hat{W}_{\sigma}^* \gg 0$ .

(v)  $\alpha^*$ , the von Neumann growth rate, is bounded.

To prove convergence, we only have to show that the sequence  $\{\alpha_{\sigma}^*\}$ ,  $\sigma = 1, 2, \dots$ , is strictly increasing. Then by (v) above, it is convergent.

As is well known, any zero sum matrix game can be solved by linear programming (Dorfman, *et al.*, 1958, Chapter 16). The linear programming problem corresponding to the game with a payoff matrix  $M_{\sigma}(\alpha_{\sigma}^*)$  is:

Minimize  $v_{\sigma}(\alpha_{\sigma}^*)$  with respect to  $P_{\sigma}$  subject to

$$v_{\sigma}(\alpha_{\sigma}^*) e - M_{\sigma}'(\alpha_{\sigma}^*) P_{\sigma}' \geq 0 \quad (A-4)$$

and

$$e' P_{\sigma}' = 1 \quad P_{\sigma} > 0 \quad (A-5)$$

where  $e$  is an  $(N_X + 1)$  vector with unit elements.

By virtue of (iii) above, we know that

$$v_{\sigma}(\alpha_{\sigma}^*) = 0$$

and by the computation procedure

$$M'_\sigma(\alpha_\sigma^*)P_{\sigma'}^{*'} = 0,$$

and  $e'P_{\sigma'}^{*'} = 1$  with  $P_{\sigma'}^* > 0$ . Hence,  $v_\sigma(\alpha_\sigma^*)$  and  $P_{\sigma'}^*$  constitute a solution to the linear programming problem.

Notice, however, that, since the columns of  $\bar{M}_\sigma(\alpha_\sigma^*)$  are not independent, one row of equation (A-4) may be deleted without changing the constraints. Let us, then, remove the row corresponding to the activity replaced in step (d). Let  $\bar{M}_\sigma(\alpha_\sigma^*)$  and  $\bar{e}$  be the reduced  $\bar{M}_\sigma(\alpha_\sigma^*)$  and  $e$ , respectively, and form a new linear programming problem as follows:

Minimize  $v_{\sigma+1}(\alpha_\sigma^*)$  with respect to  $P_{\sigma+1}$ , subject to

$$v_{\sigma+1}(\alpha_\sigma^*)\bar{e} - \bar{M}'_\sigma(\alpha_\sigma^*)P'_{\sigma+1} \geq 0, \quad (\text{A-4a})$$

$$v_{\sigma+1}(\alpha_\sigma^*) - m'_{\sigma+1}(\alpha_\sigma^*)P'_{\sigma+1} \geq 0, \quad (\text{A-4b})$$

and

$$e'P'_{\sigma+1} = 1 \quad (\text{A-5a})$$

where  $m_{\sigma+1}(\alpha_\sigma^*) = t_{i,\sigma+1} - \alpha_\sigma^* b_{i,\sigma+1}$  corresponds to the activity for which  $g_{i,\sigma}$  is positive and the largest element of  $G_\sigma$ ; that is,  $(t_{i,\sigma}, b_{i,\sigma})$  is the activity marked for inclusion in the next  $(\sigma + 1\text{th})$  producible selection. Since  $P_{\sigma+1}^* m_{\sigma+1}(\alpha_\sigma^*)$  is positive,  $(v_\sigma(\alpha_\sigma^*), P_{\sigma'}^*)$  does not constitute a solution to the new problem; that is, equation (A-4b) is an additional effective constraint. Hence, the minimum attainable level of  $v_{\sigma+1}(\alpha_\sigma^*)$  is higher than the minimum attainable level of  $v_\sigma(\alpha_\sigma^*)$ ; thus,

$$v_{\sigma+1}(\alpha_\sigma^*) > v_\sigma(\alpha_\sigma^*) = 0. \quad (\text{A-6})$$

But since  $v_{\sigma+1}(\alpha)$  is continuous and strictly decreasing in  $\alpha$ , and  $v_{\sigma+1}(\alpha_{\sigma+1}^*) = 0$ , we have:

$$\alpha_\sigma^* < \alpha_{\sigma+1}^* \quad (\text{A-7})$$

and the sequence  $\{\alpha_\sigma^*\}$  is strictly increasing and, therefore, converging to  $\alpha^*$ .

## Appendix B

### Definitions, Data, Sources, and Estimation Procedures

#### A general description of the estimation procedure

The present study is based on Martin and Carter's, 1962, providing the underlying industrial classification (UC classification) and the base year data for 1954. Martin and Carter's study was later supplemented by Zusman and Hoch (1965) who provided estimates on resource and capital requirement and on depreciation flows in the California economy in the base year.

The estimates given in these two major data sources were later augmented and revised. Consumption functions were estimated using income elasticities of demand given by Lee (1967), and input-output coefficients for the water supplying sectors were obtained from a study by Hoch and Phillips (1970).

Considerable technological progress was made during the analyzed period. In order to take account of this development, technical and resource use coefficients had to be lowered over time. This was done by developing a set of adjustment factors for each resource and sector in the economy. The adjustment factors were estimated from information available in several sources.

In subsequent phases of the analysis, a time series of output by UC classification was developed mostly from primary sources. For the nontradable sectors of the economy, this provided a unique opportunity to compare observed output with the derived domestic demands obtained by applying the estimated technical and behavioral relations to actual outputs. Discrepancies detected in this comparison led to the revision of base-year estimates, particularly those related to the construction

sector. The revised estimates were used in the derivation and analyses presented in the text.

#### The UC classification

The UC sector classification was developed by Martin and Carter (1962). A major portion of this summary description is a direct citation of their work.

**UC 1—meat animals and products**—includes cattle and calves kept for meat, hogs, sheep and lambs, and wool and mohair. Meat produced by the dairy sector is allocated to UC 27.

**UC 2—poultry and eggs**—includes farm and nonfarm eggs, farm and nonfarm chickens, broilers, turkeys and turkey eggs, other poultry and their eggs, and poultry hatcheries.

**UC 3—farm dairy products**—includes fluid milk, cream and the by-products, and dairy animals slaughtered for meat.

**UC 4—food and feed grains**—includes wheat, rye, rice, corn for grain, barley, oats, grain sorghum for grain, corn for silage and forage, and grain sorghum for silage and forage.

**UC 5—cotton**—includes cotton lint and cottonseed. It excludes cotton linters which are a by-product of the oil mill industry.

**UC 6—vegetables**—includes four classes of vegetables and truck crops: (1) miscellaneous vegetables including strawberries, tomatoes, and sweet corn (2) melons; (3) potatoes and sweet potatoes; and (4) dry beans and peas.

**UC 7—fruits and tree nuts (excluding citrus)**—is composed of five subsectors: (1) deciduous fruits, including apples, apricots, sweet cherries, nectarines, peaches, pears, persimmons, prunes, plums, and pomegranates; (2) semi-

tropical noncitrus, including avocados, dates, figs, and olives; (3) grapes; (4) tree nuts; and (5) bushberries, including blackberries and boysenberries.

**UC 8—citrus**—includes oranges, tangerines, satsumas, grapefruit, lemons, and limes.

**UC 9—forage**—is composed of hay and pasture. Corn and sorghum used for forage or silage are excluded here and included in UC 4.

**UC 10—miscellaneous agriculture**—is composed of the following subsectors: (1) legumes and grass seed; (2) vegetables seed and greenhouse and nursery products; (3) on-farm forest products; (4) sugar beets; (5) oil crops; (6) miscellaneous crops, including hops and broom-corn; (7) honey and beeswax; (8) on-farm horsepower, mule power, and horse and mule slaughter; (9) agricultural services, including custom work and machinery hire; and (10) fishing.

**UC 11—grain mill products**—is defined on an establishment basis and is identical with the census industries 2041–2045.<sup>79</sup> The subsectors of UC 11 are (1) flour and meal; (2) prepared feeds, (3) cereal breakfast foods, (4) rice milling, and (5) blended and prepared flour.

**UC 12—meat and poultry processing**—has three main components generally comparable to census industries 2011 (meat packing), 2013 (prepared meats), and 2015 (poultry dressing plants).

**UC 13—dairy products**—is defined on an establishment basis identical to census industries 2021–2025. The component subsectors of UC 13 are (1) creamery butter, (2) natural cheese, (3) concentrated milk, (4) ice cream and ices, (5) special dairy products, and (6) fluid milk and other products.

**UC 14—canning, preserving, and freezing**—is comparable to census indus-

tries 2031–2037 and is classified on an establishment basis. The subsectors of UC 14 are (1) canned seafood, (2) cured fish, (3) canning and preserving food, (4) dehydrated fruit and vegetables, (5) pickles and sauces, (6) packaged seafood, and (7) frozen fruit and vegetables.

**UC 15—miscellaneous agricultural processing**—is defined on an establishment basis and consists of the following subsectors: (1) bakery products, (2) sugar, (3) miscellaneous food and preparations, (4) alcoholic beverages, and (5) tobacco products.

**UC 16—chemicals and fertilizers**—consist of subsectors (1) industrial inorganic chemicals; (2) industrial organic chemicals; (3) plastic materials; (4) synthetic rubber; (5) explosives and fireworks; (6) drugs and medicines; (7) soap and related products; (8) paints, varnishes, and allied products; (9) gum and wood chemicals; (10) miscellaneous chemical industries; (11) fertilizers; and (12) vegetable and animal oils.

**UC 17—petroleum**—is composed of the subsectors (1) crude petroleum and natural gas, (2) petroleum products, (3) coke and products, and (4) paving and roofing materials.

**UC 18—fabricated metals and machinery**—is defined on an establishment basis and consists of the subsectors: (1) tin cans; (2) cutlery, tools; (3) plumbing and heating equipment; (4) structural metal and boiler shop production; (5) metal stamping; (6) lighting fixtures; (7) miscellaneous fabricated metal; (8) engines and construction machinery; (9) industrial machinery; (10) machine shops; (11) wiring and electrical apparatus; (12) electrical appliances; (13) finished electrical equipment; (14) motor vehicles; (15) ships and boats; and (16) railroad equipment.

**UC 19—aircraft and parts**—is defined

<sup>79</sup> The census industry number refers to the Standard Industrial Classification (SIC) system of the U. S. Department of Commerce; for further details, see U. S. Bureau of the Census (1957b).

on an establishment basis. No information of subsector breakdown is given by Martin and Carter (1962).

**UC 20—primary metals**—is defined on an establishment basis. Components of this sector are (1) steel, (2) foundries and forging, (3) nonferrous metals, and (4) nonferrous foundries.

**UC 21—other manufacturing**—is defined on an establishment basis. The components of this sector are (1) textile products; (2) apparel, house furnishings; (3) logging and fabricated wood products; (4) furniture; (5) paper products; (6) printing and publishing; (7) rubber products; (8) leather products; (9) clay products; and (10) miscellaneous manufactured products.

**UC 22—mining**—is defined on a commodity basis. Subsectors are (1) copper, lead, and zinc; (2) other mining (metals); and (3) nonmetallic minerals.

**UC 23—utilities**—is defined on an establishment basis. Components of this sector are (1) electric light and power; (2) natural, manufactured, mixed, and liquefied petroleum gas; and (3) telephone and telegraph.

**UC 24—selected services**—consists of subsectors (1) eating and drinking establishments, hotels, motels, and tourist camps—defined on an establishment basis; (2) laundry and dry cleaning—defined on an activity basis; (3) other personal services, including photographic services, shoe repair—defined on an activity basis; (4) business services, including credit and collection agencies, building maintenance services—defined on an activity basis; (5) automobile and garage repair—defined on an activity basis; (6) other repair services, including electrical repair shops, watch, clock and jewelry repair—defined on an activity basis; and (7) motion picture theaters, motion picture distribution, and all

other amusements—defined on an establishment basis.

**UC 25—trade and transportation**—includes railroads, trucking, warehousing and storage, overseas transportation, other water transportation, air transportation, pipeline transportation, wholesale trade, retail trade, and local highway transportation. Output of this sector is the value of the services performed in handling or distributing goods and services. The value of the goods sold is not included in the output. Only marketing margins are included in the output of this sector. Outputs of other sectors are, therefore, expressed in "producers' value."

**UC 26—unallocated services**—is an aggregate of miscellaneous services and industries for which individual output total could not be obtained by Martin and Carter. Components included in this sector are (1) motion picture production; (2) banking and finance; (3) real estate and rentals; (4) medical, dental; (5) non-profit institutions; (6) advertising, including radio and television broadcasting; and (7) small arms and small arms ammunition.

**UC 27—scrap and by-products**—is a dummy sector whose output is the sum of scrap and by-products output of the various producing sectors. Included in the output are such by-products as farm hides, dairy culls, rice screening, molasses, beet pulp, animal oil, blast furnace gas, and waste products from various sectors.

**UC 28—noncompetitive imports.**<sup>80</sup> Net exports are defined as the difference between a sector's GDO and domestic consumption of that sector's products. Federal government purchases are included in net exports for all endogenous sectors except UC 23, UC 24, UC 25, and UC 26. Two general categories of net imports

<sup>80</sup> The term, "noncompetitive import," applies only to row 28; column 28 in table 1 (the flow table) actually refers to all trade flows with net exports being represented by positive entries.

are distinguished: (1) competitive and (2) noncompetitive. Competitive imports are imports of the same type of goods as are produced within the state. Noncompetitive imports are of three types: (1) purchases of feeder and stocker livestock and dairy cattle from out of state, (2) products produced in the United States but not in California, and (3) products not produced in the United States.

**UC 29-30—construction**—is an aggregate of Martin and Carter's sectors, UC 29 (maintenance construction) and UC 30 (new construction). Output includes all work done on force account in addition to that by construction contractors.<sup>81</sup> Construction is defined to include the design, erection, maintenance, and repair of immobile structures and utilities together with those service facilities which become an integral part of the structure. The sector's output includes construction by both private and government sectors. It also includes petroleum and gas well drilling.

**UC 31—state and local government**—includes state, county, city, special district, and school district governments. Activities which are also performed by private sectors, such as electric utilities and transportation systems, are included in the appropriate private sector. The output of public education (as measured by the value of its inputs) is distributed from UC 26. School district governments are the purchasers of this output rather than the producers. Output is defined as the services rendered by the component governments as measured by their total receipts on current account. Inputs to government are the purchases made by governments. Output flows between components of state and local government are netted out.

**UC 32—federal government.** Total receipts on current account collected in California were defined as the gross output of the federal government sector.

**UC 37\*—direct household services**—is not included explicitly in Martin and Carter's classification. UC 37\* consists of services rendered by households directly to other households. Only household inputs are, therefore, included.

**UC 33-34—inventory change**—is self-explanatory.

**UC 35\*—net private capital formation**—is a modification of Martin and Carter's gross private capital formation [UC 35]. The sector's output consists of additions to private capital capacity net of replacement costs.

**UC 41 through UC 43 and UC 51**—are auxiliary sectors introduced in the present study. They are explained on pages 9 and 25.

**UC 36-37—households**—includes expenditures for goods and services by individuals appear as purchases by the household sector. Household outputs include wages, salaries, proprietors' income, and the net value of capital services.<sup>82</sup>

### Estimation of gross interindustry flows and gross technical coefficients<sup>83</sup>

The derivation of gross interindustry flows from Martin and Carter's interindustry flows (Martin and Carter, 1962, table I-I) is identical with the one followed by Zusman and Hoch (1965) except for important revisions in the estimates of replacement flows and net imports.

Gross interindustry flows were derived as follows: Martin developed a table of current account transactions, a given element representing a flow of current

<sup>81</sup> Force-account construction is construction performed for an industry by its own employees.

<sup>82</sup> Martin and Carter's definition of households' output, which is inclusive of depreciation charges, has been revised in the present study by excluding replacement flows.

<sup>83</sup> For estimation of gross interindustry flows and gross technical coefficients, see tables 1 and 2.

production from sector  $i$  to sector  $j$ , with domestic production and competitive import combined in one figure. We may label this  $X_{ij}^*$ . To each element in this matrix of current flows the corresponding estimate of replacement flow is added. Replacement flow is the amount of investment needed to replace capital goods used up in the production process. The estimates of replacement flows are contained in table 8. Let us label a particular element of replacement flow as  $D_{ij}$ . Then, the addition of  $D_{ij}$  to  $X_{ij}^*$  is carried out with offsetting subtractions so that row and column totals are unaffected. Thus, there is a corresponding subtraction of  $D_{ij}$  from the  $i$ th row entry in the gross private capital formation sector (the UC 35 column). Further, there is a corresponding subtraction of  $D_{ij}$  from the  $j$ th column entry in the household row [UC 36-37]. (In practice,  $\sum_i D_{ij}$  is subtracted from the  $i$ th element in column UC 35, and  $\sum_i D_{ij}$  is subtracted from the  $j$ th element of the combined row UC 36-37.)

The flows in table 1 are equivalent to those presented in table I-I of the Martin and Carter report (1962, Appendix A) but with the following modifications:

- Competitive imports have been redistributed; in each column, competitive imports have been distributed from sector (row) UC 28 to the sectors (rows) of origin.<sup>84</sup>
- Replacement flows have been redistributed as indicated above.<sup>85</sup>
- Where necessary, modifications in

the UC 35 column entries were carried out.

- UC 37\* was included as an endogenous sector. Column 37\* was constructed using Martin and Carter's estimated flow from UC 37 to UC 37 (Martin and Carter, 1962, table I-I).
- Net imports of fabricated metals and machinery were raised from \$1,579,362,000 to \$3,030,426,000. The new import figures was obtained from the application of our system of coefficients to the observed outputs in 1954 and 1955.<sup>86</sup>

The gross technical coefficients,  $a_{ij}$ , were obtained from the gross interindustry flows using the formula

$$a_{ij} = \frac{x_{ij}}{x_j} \quad (\text{B-1})$$

where  $x_{ij}$  is the gross flow of inputs from sector  $i$  to sector  $j$  and  $x_j$  is the column total. The sum of the coefficients in each column is, therefore, equal to unity. The surplus enjoyed in 1954 by the federal government [UC 32] was regarded as structural. It was, therefore, entered as a noncompetitive import flow in column 32, row 28, of the flow table (the sum of column 31 was increased accordingly) before computing the coefficients of column 32.

### Income consumption relations

**Income coefficients.** Income payments to households were assumed to be net of depreciation charges. Income flows

<sup>84</sup> The flows resulting from the redistribution of imports are those presented in Martin and Carter table, "Available Supply and Distribution of . . . 1954" (1962, Part II).

<sup>85</sup> However, no replacement flows were added to Martin and Carter's flow inputs from UC 18 to the agricultural sectors [UC 1 through UC 10] because these flow inputs already include depreciation (Martin and Carter, 1962, p. 51).

<sup>86</sup> In our opinion, Martin and Carter's estimation procedure may greatly underestimate California demand for producers' durables originating in UC 18, because they have adopted the United States ratio of producers' durables to other fabricated metals and machinery as a basis for estimation. Because the rate of growth and, therefore, of investment in California was about twice as high, the United States ratio must be much too small. Consequently, Martin and Carter's estimate of net import by UC 18 also has a downward bias.



were, therefore, obtained from the flows of net value added given in table 1 (row UC 36-37) by subtracting the corresponding differences between depreciation charges and replacement flows obtainable from table 8. Income coefficients were then derived as ratios of each sector's income flow to its column total.

**Consumption functions** were initially defined and estimated on a per-capita basis. Aggregate consumption functions were then obtained through multiplication by population size. The estimation procedure was as follows: 1954 consumption by commodities given in column UC 36-37 of table 1 was divided by 1954 California civilian population (California Interdepartmental Research Coordinating Committee, 1966). Denote the resulting per-capita consumption expenditures by  $c_i, 1954$ . The slope coefficients of the corresponding per-capita consumption functions were then estimated using the income elasticities,  $\alpha_i$ , cited by Lee (1967, p. 79) by means of the relation

$$c_{1i} = \alpha_i \frac{c_i, 1954}{y_{1954}} \quad (B-2)$$

where  $y_{1954}$  is per-capita income in 1954 obtained from table 1 after division by civilian population.

The intercepts of the per-capita consumption functions were then derived using the relation

$$c_{0i} = c_i, 1954 - c_{1i}y_{1954}. \quad (B-3)$$

### The capital/output relations

The coefficients in table 5 represent the amount of capital investment re-

quired for the expansion of \$1.00 in the productive capacities of individual sectors. They consist of investment in building, equipment, and inventories. The estimated capital coefficients are essentially the "combined capital coefficients" of Zusman and Hoch (1965, tables 10 and 11). However, the original capital coefficients had to be revised because an application of the technical coefficients and original capital coefficient to observed outputs during 1954-1964 generated a domestic demand for construction exceeding the observed output by a substantial margin. Because output of the construction sector is nontradable, the discrepancy could not have been attributed to imports. An adjustment coefficient of .73 was, therefore, applied to all capital coefficients originating in the construction sector. The value of the adjustment coefficient was computed from the total excess domestic demand for construction during the entire period.<sup>87</sup> The resulting matrix of combined capital coefficients is given in table B-1.

### Levels of accumulated stocks in 1954.

Estimated levels of 1954 capital stocks by using UC sectors were obtained as products of capital coefficients by the sectors' 1954 GDO (table 6).

**The Investment Matrix, W.** Each entry in the investment matrix was obtained by dividing the corresponding element in table B-1 by the column total. Columns of table 7 thus add up to 1.

### Replacement and depreciation

Zusman and Hoch (1965, table 13)

<sup>87</sup> Domestic demand for construction depends on the rate of replacement flows while the latter depends, in turn, on the capital coefficients. The adjustment coefficient was, therefore, calculated as follows:

$$\begin{aligned} \text{adjustment coefficient} &= 1 - \frac{\text{excess domestic demand for construction}}{\text{gross investment in construction}} \\ &= .73 \end{aligned}$$

where the denominator and numerator were both obtained in calculations employing the original capital coefficients.

APPENDIX TABLE B-1  
COMBINED CAPITAL COEFFICIENT MATRIX, CALIFORNIA, 1954

UC sector	UC investing industry										
	1	2	3	4	5	6	7	8	9	10	11
	<i>dollar per dollar†</i>										
1.....	.991692										
2.....		.190162									
3.....			.833610								
4.....	.003908	.005891	.003875	.343276						.003611	.032034
5.....					.506923						
6.....						.010230				.020035	
7.....							.001336				
8.....								.014935			
9.....	.022514		.028040						.009844	.002463	.001810
10.....	.005483		.000924	.018407	.075097	.027658	.110915	.122242	.059697	.366524	.000097
11.....	.004296	.026638	.016058							.000097	.035882
12.....										.001343	.000579
13.....											.000269
14.....											.000257
15.....										.002054	.003351
16.....	.000335	.000340	.000784	.030274	.039494	.023270	.171926	.167033	.040712	.012296	.001641
17.....	.000211	.000268	.000589	.009206	.005359	.006850	.081404	.068041	.017588	.005560	.000149
18.....	.012109	.116997	.097722	.486672	.554005	.168233	.377041	.410611	.469156	.426225	.056869
19.....											
20.....											
21.....	.008710	.021240	.007420		.002254	.037130	.172035	.225139	.004258	.025833	.005525
22.....				.000048	.000158	.000131	.001371	.001324	.000313	.000093	.000013
23.....				.001322	.002176	.002308	.026373	.025932	.001792	.000909	
24.....				.008930	.004872	.006603	.074871	.069470	.020406	.003379	
25.....	.009580	.036049	.029153	.133596	.150000	.075182	.219404	.288657	.156065	.114513	.019000
26.....				.003824	.005863	.004726	.049478	.064911	.013224	.002031	
27.....	.002299	.000312	.062948							.000251	.009530
28.....											
29-30.....	.065426	.260162	.358020	.025149	.059967	.033591	.023381	.027099	.054154	.022993	.032515
31.....	.000039	.000168	.000200	.017798	.017196	.016795	.096920	.163867	.058320	.007972	.000036
32.....	.000806	.003463	.004097	.006197	.008508	.005329	.019076	.027762	.010539	.005099	.000754
37.....											
Total.....	1.127466	.660290	1.398458	1.084705	1.431932	.418036	1.425581	1.662023	.946018	1.025781	.200023

estimated the 1954 depreciation charges in each UC sector by industry of origin of the capital good. Their estimates are based on the life expectancy of the various capital goods, on the capital structure of each sector, and on the assumption that the age distribution of existing capital stocks corresponds to a stationary economy. Replacement flows are then equal, by definition, to depreciation charges.

The flows given in table 8 were obtained from Zusman and Hoch (1965) with two major revisions. First, since all capital coefficients related to stocks originating in the construction sector were lowered by 27 per cent, a similar

adjustment in replacement flows was also performed. Second, because the rate of growth of output in California during the analyzed period was fairly high, the age distribution of accumulated capital goods was much younger than the age distribution in a stationary economy. Consequently, replacement flows had to be recalculated and distinguished from depreciation flows. The recalculation of replacement flows was based on the following functional relationship existing between the rate of replacement and the rate of growth of investment.

Let  $\theta$  be the life expectancy of the capital goods (in years, say) and let  $\epsilon$  be the annual rate of growth of investment.

APPENDIX TABLE B-1—Continued

UC sector	UC investing industry										
	12	13	14	15	16	17	18	19	20	21	22
	dollar per dollar†										
1.....	.067766									.000001	
2.....	.007570	.000002		.000281							
3.....		.013895									
4.....				.000362	.000016						
5.....										.000051	
6.....			.008580	.000819							
7.....			.011531	.004805	.000029						
8.....			.000746								
9.....											
10.....			.003777	.005148	.000763					.000136	
11.....	.000033	.000010	.000523	.009828	.000378				.000031		
12.....	.041161	.000097	.000954	.002825	.003214					.000106	
13.....	.000119	.026281	.000050	.001675	.000103					.000020	
14.....	.000267	.000052	.181779	.001192	.000150						
15.....	.000673	.001222	.005859	.127213	.002685		.000001		.000001	.000085	
16.....	.000990	.000159	.001661	.012977	.107453	.002517	.003809	.004544	.000961	.006330	
17.....	.000119	.000068	.000077	.000498	.003271	.106578	.000677	.002584	.003504	.001283	
18.....	.040272	.105336	.124017	.184512	.230976	.223059	.345775	.367054	.309157	.199083	.484205
19.....							.000188	.073795			
20.....				.003299	.094682	.044159	.055913	.101205	.003778	.002568	
21.....	.002283	.003663	.005134	.011884	.019189	.056778	.019607	.041692	.014218	.118378	.002160
22.....				.000024	.001854	.000132	.000075		.004355	.001291	.081261
23.....							.000024				.012755
24.....							.003159				
25.....	.012067	.024534	.027722	.048442	.007925	.086272	.057796	.017549	.011271	.052087	.109519
26.....							.000050				
27.....	.005463				.000839		.000285	.009956	.003166		
28.....	.000197			.011548	.001736	.000021	.000626	.003818	.013948	.000792	
29-30.....	.032775	.057804	.088761	.098457	.061366	.354568	.116171	.081845	.313379	.131505	.156722
31.....	.000031	.000069	.000086	.000117	.000106	.000303	.000139	.000130	.000243	.000135	.000268
32.....	.000628	.001403	.001773	.002406	.002193	.006266	.002840	.002692	.005016	.002791	.005509
37*											
Total.....	.212419	.234596	.463040	.525013	.453545	.931176	.595381	.661572	.780455	.517852	.854967

Then the stock of capital goods at the beginning of year  $t$  is:

The rate of replacement,  $\delta$ , is

$$K_t = \sum_{k=t-\theta}^{t-1} I_k$$

$$\delta = \frac{I_{t-\theta}}{K_t}$$

$$= \frac{\epsilon}{(1 + \epsilon)^\theta - 1}$$

(B-5)

$$= I_{t-\theta} \sum_{k=1}^{\theta} (1 + \epsilon)^k$$

$$= I_{t-\theta} \frac{(1 + \epsilon)^\theta - 1}{\epsilon}$$

(B-4)

Notice that the rate of depreciation is equal to  $1/\theta$ . Hence, to obtain replacement flows from given depreciation charges, multiply depreciation by the factor<sup>88</sup>

$$\delta\theta = \frac{\theta\epsilon}{(1 + \epsilon)^\theta - 1}$$

<sup>88</sup> Using Le Hospital rule, it can be shown that

$$\lim_{\epsilon \rightarrow 0} (\delta\theta) = 1.$$

APPENDIX TABLE B-1—Continued

UC sector	UC investing industry									
	23	24	25	26	27	28	29-30	31	32	37*
	dollar per dollar†									
1.....			.002493							
2.....			.002946							
3.....										
4.....			.001459							
5.....			.002116							
6.....			.004710							
7.....			.000925							
8.....			.000384							
9.....										
10.....			.001516							
11.....	.000003	.000425	.004807	.000008						
12.....	.000852	.003403	.017150	.000126						
13.....	.000213	.002614	.008674	.000045						
14.....	.000134	.001709	.005317	.000030						
15.....	.000364	.007644	.042221	.000087			.000005			
16.....	.005856	.001460	.015392	.000368			.001781			
17.....	.041495	.000916	.022081	.000076			.001741			
18.....	1.574622	.119055	.864025	.050609			.115476			
19.....		.000029	.009819							
20.....	.259242	.000012	.017307	.000033			.004803			
21.....	.100321	.071276	.190452	.077843			.016224			
22.....	.001393		.000260				.001108			
23.....										
24.....	.047545									
25.....	.448049	.047502	.179305	.036557			.035902			
26.....				.032615						
27.....	.000435		.003189				.000093			
28.....	.003766	.000002	.000117	.000005			.000003			
29-30.....	1.012880	.291423	.391390	3.039132			.010148			
31.....	.001228	.000198	.000497	.001413			.000046			
32.....	.025287	.004076	.010220	.029036			.000926			
37*.....										
Total.....	3.523285	.551744	1.805112	3.268883			.188256			

† Dollar invested per dollar expansion in productive capacity. (Productive capacity refers to the physical plant of a given sector and is measured here by maximum possible annual output of the given sector. Dollars invested includes investment in capital stock and inventories.)

‡ Blanks indicate zero or approximately zero stocks.

Only capital goods originating in UC 18 and UC 29-30 have a sufficiently large  $\theta$  to merit the recalculation of replacement flows. Three types of sectors were distinguished: (1) stagnant sector for which  $\epsilon = 0$ , (2) slow-growing sectors for which  $\epsilon = .030$  was used, and (3) rapidly growing sectors for which  $\epsilon = .065$  was used. For goods originating in UC 18, the value of  $\theta = 6$  was used; and for goods originating in UC 29-30, the value  $\theta = 30$  was adopted. These two figures were suggested by the ratio of total 1954 depreciation of capital goods originating in each sector to the corres-

ponding level of existing capital stocks. The bracketed figures in table 8 are the recalculated replacement flows.

### Primary resources—requirements, utilization, and availability

Primary resources requirement coefficients and utilization are those estimated by Zusman and Hoch (1965). However, because of a change in the reported statistics of agricultural employment, it was necessary to revise the corresponding labor coefficients and labor utilization figures. In particular, 1954 employment in "agriculture, forestry,

and fisheries" reported in 1966 (California Interdepartmental Research Coordinating Committee, 1966) is 378,000 employees, whereas the 1958 report cites a figure of 478,000 employees (California Department of Industrial Relations, 1958). Because Zusman and Hoch estimates were based on the 1958 report, all labor requirements and coefficients were deflated to conform to the 1966 report.

Levels of full civilian employment, civilian employment in nonagricultural sectors, and total cropland on farms and irrigable land for 1954 were adopted from Zusman and Hoch (1965, table 7). Water supply potentials of the three water supplying sectors were taken from Hoch and Phillips (1970).

### Auxiliary water supply and irrigation sectors

Gross technical coefficients, capital/output coefficients, and resource requirement coefficients of the water supplying sectors UC 41, UC 42, and UC 43 were obtained from Hoch and Phillips (1970). Similar data for the "irrigated land" activity were adopted from Zusman and Hoch (1965).

As indicated on page 25, the investment matrix,  $W$  (table 7), was augmented by adding columns and rows corresponding to the auxiliary sectors. In the row corresponding to UC 41 were entered the water coefficients associated with establishment of new fruit orchards, and in the row corresponding to UC 51 were entered irrigated land coefficients associated with this investment activity.

The water coefficients,  $W_{41,7}$  and  $W_{41,8}$ , were estimated as follows: Let the number of years from planting to fruit bearing in the  $j$ th sector be denoted by  $\eta_j$  ( $j = 7, 8$ ) and assume that the annual water consumption during this period is increasing by equal increments, with zero consumption in the first year. If the water coefficient of the sector (water

requirement for fruit-bearing groves) is  $a_{41,j}$  ( $j = 7, 8$ ), then the annual increment is  $a_{41,j}/\eta$  and water consumption during the establishment period is

$$a_{41,j} \frac{(\eta_j - 1)}{2};$$

and, hence,

$$W_{41,j} = \frac{a_{41,j}(\eta_j - 1)}{2b_j} \quad (\text{B-6})$$

where  $b_j$  is the overall capital/output coefficient of sector  $j$  ( $j = 1, 2$ ). The values  $\eta_j$  used in computing  $W_{41,7}$  and  $W_{41,8}$  were  $\eta_7 = 5$  and  $\eta_8 = 7$ .

The irrigated land investment coefficients were obtained using the formula

$$W_{51,j} = \frac{a_{51,j}}{b_j}$$

$$j = 7, 8.$$

Household average propensity to consume water,  $c_{1,41}$ , was calculated by dividing 1954 household water consumption taken from information given in Zusman and Hoch (1965) by the 1954 household income derived from 1954 outputs using the income coefficients of table 3.

### Outputs by UC sectors, 1955–1964

The description of California growth and trade during the period 1954–1963 presented on pages 26 ff. was based on the estimated outputs of the various sectors of the economy. Estimates of consumption, investment, and trade were derived from sectoral outputs with the aid of the system of relations and estimated parameters presented on pages 5 ff. and 16 ff.

In estimating the output levels during the analyzed period, we adhered, to the extent possible, to Martin and Carter's definitions and data sources. Values of

output were usually estimated at current prices and then deflated to the 1954 price level.<sup>89</sup>

**UC 1—meat animals and products—** output was defined by Martin and Carter to include cash values of sales; home consumption; inventory changes of cattle and calves for meat, hides, hogs, sheep, and lambs; and sales of mohair and wool. Cash receipts from marketing of cattle and calves plus the value of home consumption were obtained from the U. S. Agricultural Marketing Service (1956c) and U. S. Department of Agriculture, Statistical Reporting Service (1961b and 1967b) as were inventory numbers for January 1 of each year. Inventory changes were valued at the California average farm inventory value per head as of January 1 of each year (California Crop and Livestock Reporting Service, 1966a). The value of hides production was estimated on the assumption that it constituted a constant proportion of the value of output of cattle and calves. The 1954 proportion implied by Martin and Carter's figures was applied in all other years. Value of cash receipts; home consumption; and inventory numbers of hogs, sheep, and lambs in California were obtained from the U. S. Agricultural Marketing Service (1956c) and U. S. Department of Agriculture, Statistical Reporting Service (1961b and 1967b). Cash receipts for wool and mohair were obtained from the California Crop and Livestock Reporting Service (1953-54 through 1967-68).

A price index for UC 1 was calculated and used to deflate the annual values of output. A price series for cattle and calves for meat was derived by dividing California annual cash receipts for farm marketing by the annual volume of farm

marketing, both obtained from the U. S. Agricultural Marketing Service (1956c) and U. S. Department of Agriculture, Statistical Reporting Service (1961b and 1967b). A price index for sheep and lambs was similarly obtained. A wool price series was obtained from the California Crop and Livestock Reporting Service (1966a) as was a hog price series. Subsector price indices were derived from the price series. They were aggregated to a sector price index using values of output as weights.

**UC 2—poultry and eggs.** Martin and Carter defined this sector output as cash receipts for chickens, eggs, broilers, and turkeys plus value of home consumption and value of inventory changes plus value of commercial hatchery production.

Annual cash receipts from farm sales and value of farm home consumption of turkeys in California were obtained from the U. S. Agricultural Marketing Service, Crop Reporting Board (1956d) and U. S. Department of Agriculture, Statistical Reporting Service (1961c and 1967c) as were inventory numbers of turkeys on January 1 of each year. Annual inventory changes were valued at the annual average value per head of turkey on California farms (California Crop and Livestock Reporting Service, 1966a). Annual output of turkey eggs was estimated on the assumption that it constituted a constant proportion of turkey output.<sup>90</sup>

California annual cash receipts for farm chickens and eggs and the value of chickens consumed on farms were obtained from the U. S. Agricultural Marketing Service, Crop Reporting Board (1956a) and U. S. Department of Agriculture, Statistical Reporting Service

<sup>89</sup> In the following, deflation of a sector's value of output by the sector's price index always implies the transformation of output values to 1954 prices.

<sup>90</sup> Whenever an assumption of constant proportion is made, the 1954 proportion implied by Martin and Carter (1962) estimates is used.

(1961a and 1967a) as were annual inventory numbers of chickens on farms as of January 1. Annual inventory changes were valued at the average annual value per head of chickens on California farms (California Crop and Livestock Reporting Service, 1966a). The Martin and Carter correction for non-farm chickens (increase of 5 per cent) was then applied. Broiler output was obtained as the annual gross income for commercial broilers (U. S. Agricultural Marketing Service, Crop Reporting Board, 1956a, and U. S. Department of Agriculture, Statistical Reporting Service, 1961a and 1967a). Value of output by commercial hatcheries was assumed to constitute a constant proportion of turkey and chicken output. The same assumption was made with respect to "other poultry and eggs."

The total output series for UC 2 was deflated by a price index constructed for this sector. The price index was constructed from prices received by California farmers for turkeys, chickens, broilers, and eggs (U. S. Agricultural Marketing Service, Crop Reporting Board, 1956a and 1956d, and U. S. Department of Agriculture, Statistical Reporting Service, 1961a, 1961c, 1967a, and 1967c). Values of outputs of the various components for 1954 served as weight in constructing the sector's price index.

**UC 3—farm dairy products**—output consists of cash receipts and value of on-farm consumption of fluid milk, cream and by-products, and dairy animals slaughtered for meat.

Cash receipts for marketing of all milk and cream in California were available in the California Crop and Livestock Reporting Service (1966b).

Values of the other output components were estimated on the assumption that they constitute a constant proportion of cash receipts for marketing of all milk and cream.

Values of output were deflated by a price index constructed for this sector. The price index was calculated from a time series of prices received by California farmers for all whole milk sold at wholesale to processing plants (California Crop and Livestock Reporting Service, 1962a and 1966b).

**UC 4—food and feed grains**—output consists of the value of output of the component crops. Annual value of output of wheat, rye, rice, and all corn (grain, silage, and forage) were obtained from the California Crop and Livestock Reporting Service (1958 and 1967). For some years, figures concerning production of sorghum and corn for silage and forage were missing. The missing output figures were estimated, assuming constant proportionality with the production of grains.

The output series was deflated by a price index calculated for this sector. The sector's price index was a weighted average of price indices of individual crops with the 1956 values of output serving as weights. Price indices for individual crops were calculated from price series available in the California Crop and Livestock Reporting Service (1958 and 1967).

**UC 5—cotton.** Value of output consists of value of cotton lint and cottonseed. Value of production for both were obtained from the California Crop and Livestock Reporting Service (1958 and 1967). A price index was calculated for the sector used in deflating annual outputs. California average annual farm prices for cotton lint and cottonseed were used in constructing the sector's price index (California Crop and Livestock Reporting Service, 1958 and 1967). Output values for 1954 served as weights.

**UC 6—vegetables.** Annual values of production of all vegetables in California were obtained from the California Crop and Livestock Reporting Service (1965b).

To these were added values of production of dry beans and peas and sweet potatoes and all other potatoes (California Crop and Livestock Reporting Service, 1958 and 1967). The output series so obtained was deflated by a price index constructed for this sector. The price series used in the construction was annual average California farm prices for dry beans and sweet potatoes and other potatoes (California Crop and Livestock Reporting Service, 1958 and 1967); and a price index of vegetables was obtained as a ratio of total annual value of production to quantity of output (California Crop and Livestock Reporting Service, 1965b). The sector's price index is a weighted average of the two price indices with 1954 values of output serving as weights.

**UC 7—fruits and nuts (excluding citrus)**—annual output was obtained as the value of production of deciduous tree fruits, grapes, semitropical tree fruits (exclusive of citrus), and tree nuts from the California Crop and Livestock Reporting Service (1962b, 1964, and 1965a). The output series was deflated by a price index calculated for the sector. Annual prices for individual subsectors were obtained from value and production figures (California Crop and Livestock Reporting Service, 1962b, 1964, and 1965a) and then used in constructing the sector's index. Values of output for 1954 served as weights.

**UC 8—citrus.** Annual value of production was obtained from the California Crop and Livestock Reporting Service (1962b, 1964, and 1965a). The output series was deflated by a price index derived from average annual prices. Prices were obtained as ratios of annual value of production to annual quantity produced (California Crop and Livestock Reporting Service, 1962b, 1964, and 1965a).

**UC 9—forage.** Annual California value

of production of all hay was obtained from the California Crop and Livestock Reporting Service (1958 and 1967). Output of pasture was assumed to maintain constant proportion to the value of output of hay. The estimated output series was deflated by a price index calculated from annual average prices received by California farmers (California Crop and Livestock Reporting Service, 1958 and 1967).

**UC 10—miscellaneous agriculture.** Value of output is the sum of the value outputs of its components. Annual output data for alfalfa seed and major grass seed are presented by the California Crop and Livestock Reporting Service (1958 and 1967). In some years the information is not complete, and the missing data were estimated on the assumption of constant proportion with reported value of production of alfalfa seed. Annual vegetable seed and nursery and greenhouse products output is not available by states. Value of output for these products was, therefore, estimated also on the assumption of constant proportion with the value of output of the legume and grass seed subsector. Annual value of sugar beet and flaxseed production in California was available in the California Crop and Livestock Reporting Service (1958 and 1967). Annual value of oilseed production was estimated assuming constant proportion with flaxseed output. Value of California output of hops was available in the California Crop and Livestock Reporting Service (1958 and 1967). Outputs of miscellaneous crops were estimated assuming constant proportion with the output of hops.

Annual cash receipts of farm marketings of honey and beeswax were obtained from the California Crop and Livestock Reporting Service (1957 and 1966a). The annual output of the farm horse and mule subsector was estimated from the



1954 figure (Martin and Carter, 1962) on the assumption that it is proportional to the number of horses and mules on farms. The latter statistics for 1953–1960 were available from U. S. Agricultural Marketing Service, Crop Reporting Board (1956b and 1961). For 1961–1964 it was obtained by linear extrapolation. The value of annual on-farm output of forest products in California was estimated from the 1954 figure (Martin and Carter, 1962) on the assumption that it is proportional to the United States lumber production (U. S. Bureau of the Census, 1954 through 1960). The annual value of output of agricultural services was estimated from the 1954 figure (Martin and Carter, 1962) on the assumption that it is proportional to total annual cash farm receipts in California (Tsukui, 1968). Annual value of output of California fisheries for 1953–1964 was obtained from U. S. Bureau of the Census (1954 through 1960).

The resulting value of output for UC 10 was deflated using the wholesale price index (all commodities) (U. S. Bureau of the Census, 1957b).

**UC 11—grain mill products.** The procedure of Martin and Carter (1962, pp. 35 and 36) was followed in estimating output (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b), with transfers into each sector calculated from Martin and Carter's estimates on the assumption of constant proportions with the sector's output.

Output of UC 11 in 1954, 1958, and 1963 consists of the value of shipments adjusted for inventory change plus value of transfers in. The value of output for each year was deflated by the index of wholesale prices (all commodities) (U. S. Bureau of the Census, 1954 through 1960). Output for noncensus years was obtained by logarithmic interpolation.<sup>91</sup>

<sup>91</sup> Logarithmic interpolation was carried out graphically by plotting on semi-logarithmic graph paper.

## **UC 12—meat and poultry processing.**

Outputs (meat packing, prepared meats, and poultry dressing) were estimated for 1954, 1958, and 1963 as described for UC 11 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b). Adjustment of meat packing for slaughter in wholesale branches in 1958 and 1963 was made using the 1954 ratio between "slaughter in wholesale branches" and the output of meat packing (Martin and Carter, 1962). The same procedure was applied in adjusting output of prepared meats in 1958 and 1963 for meat prepared in wholesale branches.

The estimated outputs for the census years were deflated by the wholesale price index (all commodities). Outputs in noncensus years were then obtained as described for UC 11.

**UC 13—dairy products.** Production of the primary subsectors was obtained as described in UC 11 for the years 1954, 1958, and 1963 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b). Output figures were then deflated by an index of wholesale prices (dairy products and ice cream) obtained from the U. S. Office of Business Economics (1967).

**UC 14—canning, preserving, and freezing.** Gross domestic output for the sector in 1954, 1958, and 1963 was calculated as for UC 11 (U. S. Bureau of the Census, 1949, 1957b, 1961b and 1966b). The output estimates were then deflated by an index of wholesale prices (fruits and vegetables, canned and frozen). Because employment in this sector (California Interdepartmental Research Coordinating Committee, 1958 through 1967) fluctuated annually, output for noncensus years was estimated from census years outputs on the basis of employment in the "canning and preserving" industry and not by logarithmic interpolation. Presumably, output

fluctuated in the same fashion as employment.

**UC 15—miscellaneous agricultural processing.** Martin and Carter's definition corresponds to the census classification industry groups 205 through 209 and census major industry group 21 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). There were several modifications in the industrial classification. In 1958 this sector comprised census groups 205, 206, 207, 208, 2096-2099, and major group 21. In 1963 industry 2095 was added to the above. The procedure outlined for UC 11 was followed in estimating output for UC 15. Where value of shipment data for California was not listed separately from a regional figure, the procedure outlined by Martin and Carter (1962, p. 35) was followed.

The census classification of "bakery products" by establishments excludes bread baking at single retail outlets. This output was, therefore, estimated from the 1954 figures, assuming constant proportionality with the output of the bakery products subsector. Census data on value of shipments of alcoholic beverages (2082-2085) were not listed by the U. S. Bureau of the Census (1949, 1957b, 1961b, and 1966b) for either the United States or California in 1954 and 1958. The output of this subsector was, therefore, estimated from Martin and Carter's data on the assumption of constant proportionality with other components of this subsector.

The estimated outputs of the sector in 1968 and 1969 were deflated by a wholesale price index (total processed foods) which was obtained from the U. S. Office of Business Economics (1967). Output in noncensus years was estimated by interpolation as described for UC 11.

**UC 16—chemicals and fertilizers.**

Martin and Carter's definition corresponds to the 1954 census major industry group 28 (excluding 2821) plus industry 3985. The 1954 census classification was revised in 1958 and 1963 so that UC 16 then corresponded to census major industry group 28 (excluding 2814) and inedible vegetable and animal oil industries (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). Outputs for 1958 and 1963 were estimated as described for UC 15. The output estimates were then deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). Annual employment in California's "chemical and allied products" industry (California Interdepartmental Research Coordinating Committee, 1958 through 1967) served in interpolating output for 1959-1962 and 1964. For the remaining years the graphical method described for UC 11 was used.

**UC 17—petroleum.** Production data for the primary industries of the crude petroleum and natural gas were obtained from the U. S. Bureau of Mines (1954 through 1966) as the value of production of natural gas, gaslike liquids, and petroleum produced in California in 1954, 1958, and 1963. The "petroleum products" subsectors of UC 17 correspond to the 1954 census industries 2911, 2992, 2999, 2821, 2931-32, 2991, and 2951-52 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). The 1954 census classification was modified in later years so that it became impossible to identify the "coke and products" subsectors which had been reclassified into the primary metals sector.

The output of UC 17 was estimated for 1954, 1958, and 1963 as described for UC 15. An adjustment was made for the coke and products subsector in 1958 and 1963 on the assumption of constant pro-

portionality with the output of all other subsectors of UC 17. Values of output for 1958 and 1963 were then deflated by the wholesale price index (petroleum products) (U. S. Office of Business Economics, 1965). Output in noncensus years was estimated as described for UC 11.

**UC 18—fabricated metals and machinery.** Martin and Carter's definition corresponded in 1954 to census major groups 34, 35, 36 (except for 3663), and 37 (except group 372 and "aircraft and parts") plus industries 3991 and 3997 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). Some reclassification took place between the 1954 and the 1958 census.

Estimation of the sector's output in 1958 and 1963 was as described for UC 15. Data for the "beauty and barber shop equipment" could not be identified after the 1954 census and were assumed constant at the 1954 level. The resulting output estimates were deflated by an index of wholesale prices (total manufacturers) (U. S. Office of Business Economics, 1965). Output in noncensus years was estimated by graphic interpolation as described for UC 11.

**UC 19—aircraft and parts.** Martin and Carter's definition corresponds to census industry group 372 plus an adjustment for research and development (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). Output for 1954, 1958, and 1963 was estimated in the U. S. Bureau of the Census (1949, 1957b, 1961b, and 1966b) as described for UC 15. Adjustment for research and development in 1958 and 1963 was based on the ratio of total GDO of UC 19 reported by Martin and Carter and the output in 1954 as calculated from the census data.

Outputs in 1958 and 1963 thus obtained were deflated by a wholesale index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). Employment in this sector exhibited annual fluctuations, thus production in noncensus years was interpolated using annual employment data for California aircraft and parts industries available in the California Interdepartmental Research Coordinating Committee (1958 through 1966).

**UC 20—primary metals.** For certain of the major census industries corresponding to UC 20, value of shipments for both California and the United States is not reported in the U. S. Bureau of the Census (1949, 1957b, 1961b, and 1966b). It was, therefore, difficult to follow the method of output estimation outlined by Martin and Carter. For this reason, annual output for UC 20 was estimated on the assumption that it was proportional to productivity adjusted annual employment for California in primary metal industries. Martin and Carter's 1954 GDO served as a base. Annual civilian employment in this sector was obtained from the California Interdepartmental Research Coordinating Committee (1958 through 1966). A productivity factor of 1.0363 for the industry was used to adjust employment for 1955 through 1964.<sup>92</sup> The coefficient of adjustment in each year  $t$  is equal to  $(1.0363)^{t-1954}$ .

**UC 21—other manufacturing.** Martin and Carter's definition corresponded in 1954 to census major industry groups 22, 23, 24, 25, 26, 27, 30, 31, 32 (except 3281), 38, 39 (except industries 3985, 3991, 3997), and industry 3663 (U. S. Bureau of the Census, 1949, 1957b, 1961b, and 1966b, and U. S. Bureau of Labor Statistics, 1963). The census classification was somewhat modified in

<sup>92</sup> The productivity factor 1.0363 is based on annual rate of change in the labor coefficient of  $-.035029$  given in table 17.

later years. In particular, it became impossible to identify the output of industry 3999 for California in 1958. Estimated output of UC 21 for 1958 (but not for 1963) was calculated as described for UC 15 with output of 3999 taken at the 1954 level. The sector's output was then deflated by a wholesale price index (total manufacturers) which was obtained from the U. S. Office of Business Economics (1965). For other years, output estimates are assumed to be proportional to California civilian employment in industries included in UC 21, reported in the California Interdepartmental Research Coordinating Committee (1958 through 1966). Direct output estimate in 1954 served as a basis for estimating output.

**UC 22—mining.** Annual estimates of the value of output for the components of UC 22 for 1953 through 1964 were obtained from the area reports in the annual issues of the U. S. Bureau of Mines (1954 through 1966). The annual output series was deflated by a wholesale index (crude materials for later processing) (U. S. Office of Business Economics, 1965).

**UC 23—utilities.** Martin and Carter estimated output from the sum of revenue of privately and publicly owned electric utilities plus gross receipts for natural manufactured and mixed gas, adjusted upwards to account for incomplete coverage, plus gross revenue of telephone and telegraph companies.

Annual data on revenue of privately owned electrical utilities were obtained from the California Interdepartmental Research Coordinating Committee (1958 through 1966). Output of publicly owned electrical utilities was estimated from the 1954 figures on the assumption of constant proportion to revenue by privately owned electrical utilities. Annual California revenue from natural, manufactured, and mixed gas was available in

the U. S. Bureau of the Census (1954 through 1960). The ratio between this figure in 1954 and Martin and Carter's estimated output of the subsector was used to adjust the revenue figure in all other years. Annual revenue of California telephone utilities was obtained from the California Interdepartmental Research Coordinating Committee (1958 through 1966). Output of telegraph utility was estimated from Martin and Carter figures, assuming constant proportion to telephone utility.

The annual total output series for the sector was deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960).

**UC 24—selected services.** Martin and Carter estimated output by comparing the 1947 Bureau of Labor Statistics output and description of this sector components (U. S. Bureau of Labor Statistics, 1963) with receipts for the corresponding subsectors reported in the 1948 Census of Business (U. S. Bureau of the Census, 1952). Corresponding 1954 Census reports then served in obtaining output estimates for components of UC 24. The same approach was used in the present study in estimating outputs in 1958 and 1963 from Martin and Carter estimates and 1954, 1958, and 1963 Census statistics (U. S. Bureau of the Census, 1952, 1957a, 1961a, and 1966a). Output estimates thus obtained were then deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). Output in non-census years was estimated from the 1954, 1958, and 1963 outputs by an interpolation based on California employment in this sector (California Interdepartmental Research Coordinating Committee, 1958 through 1966).

**UC 25—trade and transportation.** Output was estimated in two stages. Initial output estimates were obtained from Martin and Carter's 1954 estimate

on the assumption that it was proportional to the California personal income report in the U. S. Office of Business Economics (1967) and deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). However, when domestic demand for the output of UC 25 was computed from the estimated outputs, a large discrepancy occurred. Since UC 25 is essentially a domestically, rather than trade, oriented sector, the estimated levels of output were adjusted down so as to conform closer to the general trade-to-output relationship estimated by Martin and Carter for UC 25 in 1954.

**UC 26—unallocated services.** Estimates of output were obtained from the 1954 estimates by Martin and Carter on the assumption that they are proportional to California personal income reported in the U. S. Office of Business Economics (1967) and deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). The resulting output estimated conformed adequately to the derived domestic demand calculated from the estimated outputs.

**UC 27—scrap and by-products** estimates of annual outputs were derived as described for UC 26.

**UC 28—noncompetitive imports** output was set equal to the derived demand calculated from observed outputs.

**UC 29-30—construction.** Estimates of annual output were calculated from productivity-adjusted employment figures as described for UC 20. A productivity factor of 1.0257 was used to adjust employment data obtained from the California Interdepartmental Research Coordinating Committee (1958 through 1966).<sup>93</sup>

**UC 31—state and local government** output was defined by Martin and Car-

ter to include services rendered by the component government as measured by their total receipts on current account. State revenue receipts and local government receipts in California were obtained from the California Interdepartmental Research Coordinating Committee (1966). Totals were then deflated by a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960) to yield the sector output in 1954 prices.

**UC 32—federal government** output was defined the same way as that of UC 31. Federal internal revenue figures for California were obtained from the California Interdepartmental Research Coordinating Committee (1966). Values of output for UC 32 were then calculated from the 1954 estimate by Martin and Carter on the assumption of constant proportionality to the federal internal revenues. The resulting estimates were then deflated by a wholesale price index (U. S. Bureau of the Census, 1954 through 1960).

**UC 37\*—direct household services** output was estimated as described for UC 26.

**UC 41 and 42—water supply.** Total water supply estimates are based on the total water consumption estimated for 1954 by Zusman and Hoch (1965) and an annual increment of 470,000 acre-feet, thereafter, as estimated in the California Department of Water Resources (1966). Since the capacity of UC 41 was estimated by Hoch and Phillips (1970) to be at 22,000,000 acre-feet, the rest has been supplied by UC 42.

**UC 51—irrigated land.** Irrigated acreage in California for 1954, 1959, and 1964 was obtained from the U. S. Bureau of the Census (1967). For non-census years, acreage was obtained by interpolation.

<sup>93</sup> The productivity factor is based on the rate of change in the labor coefficient given in table 17.

## California income and expenditures

California social accounts presented in table 12 were calculated from the estimated GDO (table 13) with the aid of the input-output coefficients and consumption functions given on pages 16 ff.

**Income.** *Domestic state income* was calculated from the observed outputs as follows:

$$\text{domestic state income (t)} = \sum_{j=1}^{37*} U_{jt} X_{jt}.$$

It, thus, refers to income generated within the state.

*State income* is equal to the domestic state income plus interest receipts on California foreign investment.<sup>94</sup>

*Depreciation minus replacement plus indirect business taxes* was obtained as a residual after subtracting the state income from the *NSP*. The latter was obtained as a sum of all expenditures.

**Expenditures.** *Household consumption* was obtained by summing up all consumption expenditures (exclusive of tax payments):

Household consumption in year (*t*)

$$\begin{aligned} &= \sum_{t=1}^{29-30} C_{it} + C_{37, t}^* \\ &= \sum_{t=1}^{29-30} N_t C_{io t} \\ &\quad + \left( \sum_{t=1}^{29-30} C_{it} + C_{37, 1}^* \right) \\ &\quad \text{(state income (t)).} \end{aligned}$$

*Net private domestic investment* was calculated on the assumption that it follows a simple accelerator relation. Let  $I_{it}$  be the investment by industry of origin, then

$$I_{it} = \sum_j b_{ij} (X_{j, t+1} - X_{j, t}^*)^+$$

$$i = 1, 2, \dots, 28, 31, 32$$

where

$b_{ij}$  = an element of the matrix  $B$  of capital coefficients (Appendix table B-1)

$X_{j, t}^*$  = the highest observed output of commodity  $j$  up to an including year  $t$

and

superscript  $+$  indicates that only positive values are considered.

For investment originating in UC 29-30 (construction), investment was calculated as the difference between the estimated GDO and the derived demand for noninvestment uses; that is:

$$I_{29, t} = X_{29, t} - a_{29} X_t - C_{29, 1} \quad \text{(state income (t))}$$

where  $a_{29}$  is the "a" row vector of the matrix  $A$  corresponding to sector 29-30. Total net private investment was the sum of investment originating in all sectors.

*Government purchase of goods and services.* Government expenditures included both UC 31 and UC 32. They were calculated as the sum of outputs in these two sectors net of purchases by government from government calculated with the aid of the gross technical coefficients.

*Net exports* in each trading sector were calculated as the difference between estimated outputs and domestic demands. Thus, let  $E_{it}$  be the net export originating in the  $i$ th sector; then,

$$E_{it} = X_{it} - a_i X_t - C_{io} N_t - C_{i1} \quad \text{(state income (t))} - I_{it}$$

<sup>94</sup> For the estimation of interest receipts on accumulated foreign investment, see page 108.

with a negative value signifying an import. For UC 28 the entire domestic demand was an import.

Total net exports in table 12 consist of sums of all net exports plus receipts of interest charges accrued to residents of California but exclusive of the federal surplus. *Federal surplus* was viewed as an import item and was, therefore, included in table 12 as a negative expenditure. It was set equal to  $a_{28, 32}X_{32, t}$ .

*NSP* was calculated as the sum of all expenditures; that is,

$$\begin{aligned} \text{NSP } (t) = & \text{household consumption } (t) \\ & + \text{net private domestic investment } (t) \\ & + \text{government purchase of goods and services } (t) \\ & + \text{net export } (t) \\ & - \text{federal surplus } (t) \end{aligned}$$

### California capital formation, 1954–1963 sources

**Saving out of household income.** Household saving was obtained as the difference between the state income and household consumption. *Depreciation minus replacement plus estimation discrepancy* was a residual obtained after subtracting other sources of capital formation from "all sources." Estimation of *unilateral capital transfers* is explained on page 108. *All sources* equal total net investment uses.

**Net private domestic investment.** The estimation of this variable is explained on page 106. *Net foreign investment* was calculated as follows:

$$\begin{aligned} \text{Net foreign investment } (t) = & \text{net export } (t) \\ & - \text{federal surplus} \\ & + \text{unilateral capital transfers.} \end{aligned}$$

*Total net investment* is the sum of private domestic investment and net foreign investment.

## Technological progress

Two types of technological changes were considered in the present analysis—flow inputs augmenting and primary resources augmenting. The introduction of the first type of technological change is explained on page 43.

**Changes in labor productivity in agricultural sectors.** The U. S. Department of Agriculture (1965, table 666) published indices of labor productivity by farm products. The indices are in terms of productivity per man-hour. Since the number of hours per workday have declined over the years, the productivity change alone is an overestimate. The annual rate of change in the length of workday was calculated for the period 1954–1965 from data on family and hired labor (U. S. Statistical Reporting Service, December 9, 1955, and June 10, September 10, and December 10, 1965). The labor productivity indices for 1954 and 1963 were then adjusted for the number of hours worked, and the annual rate of change in labor requirement,  $\xi_i$ , was computed solving the following equation:

$$(1 + \xi_i)^9 = \frac{I_{L, i, 54}}{I_{L, i, 63}}$$

where  $I_{L, i, t}$  is the index of labor productivity for sector  $i$  in year  $t$ , adjusted for the number of hours worked. This procedure was used for UC 1 through UC 9. The estimate rate of change for UC 10 was obtained as a simple average of the rates of all other agricultural sectors.

**Changes in labor productivity in non-agricultural sectors.** Rates of change in labor requirement were estimated from United States figures on national income and employment by sectors. The national income generated in each sector in 1954 and 1963 was obtained from the U. S. Office of Business Economics (1966) and deflated by the index of wholesale prices

(all commodities) (U. S. Bureau of the Census, 1954 through 1960). The number of employees on payrolls for these sectors in 1954 and 1963 was obtained from the U. S. Office of Business Economics (1965). The annual rate of change in labor requirement in section  $i$ ,  $\xi_i$ , was then computed as a solution to

$$(1 + \xi_i)^9 = \frac{e_{L, i, 54}}{e_{L, i, 63}} \quad -$$

where  $e_{L, i, t}$  is the national income generated per employee in the  $i$ th sector in year  $t$ . The sector classification in the U. S. Office of Business Economics (1965 and 1966) did not correspond exactly to the UC classification. Thus, one rate of change in labor requirements had to be calculated for all agricultural processing sectors. For other nonagricultural sectors, aggregates had to be formed which would be as comparable as possible to the corresponding UC sectors.

**Changes in land and water productivity.** Land and water productivity changes were assumed to be confined to crop-producing sectors alone. It was also assumed that water-land ratios did not change, and the rate of reduction in water and land requirement is equal to the rate of increase in yields. It is, therefore, equal for both land and water.

The annual rates of change in land and water requirement are calculated below. A yield index was first calculated for each sector as follows:

$$I_{A, i, 63} = \frac{\sum_k A_{k, 54} P_{k, 54} Y_{k, 63}}{X_{i, 54}}$$

where

$X_{i, 54}$  = the value of output in the  $i$ th sector in 1954

$A_{k, 54}$  = the 1954 acreage of the  $k$ th crop in the sector

$P_{k, 54}$  = the unit value of this crop in 1954

and

$Y_{k, 63}$  = its yield (per acre) in 1963. The annual rate of change in land and water,  $\eta_i$ , requirement was calculated as solutions to the equations

$$(1 + \eta_i)^9 = \frac{1}{I_{A, i, 63}}$$

$$i = 4, 5, \dots, 9.$$

The sources for outputs, prices, and yields are described in detail in the corresponding parts of pages 97 ff.

## California pattern of trade and balance of payments

**Exports and imports.** The levels of these trade variables were estimated as residual as explained for net exports on page 106.

**Interest receipts on foreign investment.** Interest receipts accruing to residents of California on their foreign investments were calculated by multiplying the interest rate of 6.3 per cent by the value of accumulated foreign investment. The interest rate was obtained from Romans (1965, p. 92). Estimation of accumulated foreign investment is explained below.

**Federal surplus.** Estimates of the federal surplus were obtained as explained on page 106.

**Unilateral transfers.** Unilateral transfers were estimated on the assumption that the wealth position of an immigrant to the state of California was the same as that of the average American. Per capita wealth in the United States in 1954-1963 was estimated as follows: Total nonwage income in the United States was calculated as the sum of "net rentals" plus "corporate profits" plus



"net interest" plus 30 per cent of "proprietor income." Estimates of these sources of income were available in the U. S. Office of Business Economics (1966). Only 30 per cent of proprietor's income was included since this source of income includes payments to labor as well as returns to capital. Total non-wage income was then deflated to the 1954 price level using a wholesale price index (all commodities) (U. S. Bureau of the Census, 1954 through 1960). The resulting figures were then divided by United States population to give per capita nonwage income. This figure was divided by .063, thus yielding an estimate of wealth (as a source of permanent returns) per capita. Unilateral transfers to California were obtained by multiplying the resulting per capita wealth by net immigration to California.

*Net borrowing* by California residents was obtained as a residual:

Net borrowing ( $t$ ) =

- net exports of goods and services
- interest receipts on foreign investment
- + federal surplus
- unilateral transfers.

The total on capital account plus the total on current accounts, thus, always add up to zero.

*Accumulated foreign investment* is defined for the end of each year. It was calculated as follows:

Accumulated foreign investment ( $t$ ) =  
 accumulated foreign investment ( $t-1$ )  
 — net borrowing ( $t$ ).

It was assumed that, at the end of 1953, accumulated foreign investment was equal to zero.

**The contribution of primary agricultural sectors to economic growth (table 21)**

**Net value added in agriculture.** The net value added in agriculture in any particular year was computed from the

observed levels of outputs  $X_{jt}$  in the agricultural sectors as follows:

Net value added in agriculture ( $t$ )

$$= \sum_{j=1}^{10} X_{jt}(1 - \sum a_{ij}^t).$$

Note that value added is net of replacement flows and indirect taxes.

**Income generated in agriculture.** This variable was computed as follows:

Income generated in agriculture ( $t$ )

$$= \sum_{j=1}^{10} U_{jt}X_{jt}.$$

**Net saving in agriculture.** Net saving in agriculture represents the net value added in agriculture less the value of consumption induced by income generated in agriculture; that is,

Net saving in agriculture ( $t$ ) =

net value added in agriculture ( $t$ )

— (.902057) (income generated in agriculture)

where .902057 is the sum of marginal propensities to consume, inclusive of public goods—that is, inclusive of direct tax rates.

**Net investment in agriculture.** This is an estimate of the value of investment in the expansion of capital capacities of the agricultural sectors. It was estimated in the same way as all investments (page 106).

**Saving transferred from agriculture to nonagricultural sectors.** This represents net capital movement between primary agriculture and the rest of the economy and was calculated as the difference between net saving and net investment in agriculture.

**Labor migration to nonagricultural sectors.** Labor migration figures were calculated as the differences in agricultural employment between successive years.

### Composition of terminal capital capacities along the expansion ray in the linear programming formulation

The expansion ray of terminal capital capacities is defined by the set of proportions,  $g_i$ , 1962, given in table 26. These proportions were computed in two steps. Projected rates of growth of each sector were first calculated on the basis of 1954 output utilization, projected rates of growth of NSP, population and exogenous exports, and the income elasticities of demand. In the second stage, 1962 capacities were projected from the 1954 capacities with the aid of the estimated sectoral rates of growth. The 1962 capacities thus obtained provided the desired proportions,  $g_i$ , 1962. The projected sectoral rate of growth,  $\xi_i$ , was obtained using the formula

$$\xi_i = W_{1i}\alpha + W_{2i}[\pi + (\alpha - \pi)\epsilon_i] + W_{3i}\xi_{ei}$$

where

$W_{1i}$ ,  $W_{2i}$ ,  $W_{3i}$  = the proportions of 1954 total supply (including imports) of the  $i$ th output used for investment and intermediate inputs, for household consumption, and for exports, respectively

$\alpha$  = the projected rate of growth of NSP

$\pi$  = the annual rate of growth of California population

$\epsilon_i$  = the income elasticity of per capita demand for the  $i$ th good

and

$\xi_{ei}$  = the projected rate of growth of exports.

The following values were used in calculating the  $\xi_i$ :<sup>95</sup> the rate of growth of NSP,  $\alpha = .065$ ; the rate of growth of population,  $\pi = .039$ ; all controllable exports were assumed to grow at the rate  $\xi_{ei} = .040$ ; and exogenous exports were projected to grow at the rates

$\xi_{e5} = .014$	$\xi_{e22} = .083$
$\xi_{e10} = .065$	$\xi_{e24} = .071$
$\xi_{e17} = -.031$	$\xi_{e25} = .059$
$\xi_{e19} = -.033$	$\xi_{e26} = .130$

The elasticities of demand  $\epsilon_i$  are those listed in table 4.

The resulting estimates of the rates of growth were then applied to the 1954 capacities given in table 6 using the formula

$$K_{i, 1962} = (1 + \xi_i)^8 K_{i, 1954}.$$

<sup>95</sup> Some of the values used in developing the  $\xi_i$  are not equal to the corresponding values given on pages 26 ff. because the first runs of the linear programming problem were made before the analysis of actual growth had been completed. The revision of the early estimates was not sufficiently large to warrant a rerun of the linear programming problem.

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