RECURSIVE ECONOMIC SYSTEMS IN RURAL-URBAN DEVELOPMENT

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To trace the economic effects of a particular decision, such as investing in a new chemical plant or increasing the property tax yield a specified amount, we have prepared a computer model of an area economy. This model has been used to generate a series of population, income and output variables that are relevant factors in rural-urban growth and development. Because of the complexity of economic development problems, however, the programming procedures are confined to simulation techniques. We are willing to concede that the decision-making problems in rural-urban development still are "hopelessly beyond our abilities to optimize".[2]

Theories of Rural-Urban Development

In the preparation of the economic model and the programming procedures, we have had the benefit of some empirical data and a variety of economic theories pertaining to regional growth and development.[3] We classify the theoretical considerations in three ways: First, the investment process itself and the interactions between demand, technology and output; second, the production and income flows of an area economy; and third, the interdependence of rural and urban activities. Of course, our classification and selection of relevant theories and techniques are influenced by our particular formulation of the basic economic problem.[4]

1/ Journal Paper No. J- of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project 1571, Center for Agricultural and Economic Development cooperating.

2/ Harry M. Markowitz and Alan J. Rowe. Future metal working analysis, In: Studies in Process Analysis. Alan S. Manne and Harry M. Markowitz (eds.) 1963. pp. 352-356.

3/ Wilbur R. Maki, Richard Suttor and Jerald R. Barnard. Computable Models of Regional Economic Development With Applications to Iowa, 1954-1974. Iowa Agricultural and Home Economics Experiment Station. (Unpublished report) 1963.

4/ For an excellent critical review of regional development studies and some of their technical contributions see: Robert G. Spiegelman, Review of Techniques of Regional Analysis, Stanford Research Institute, Menlo Park, California, June, 1962.

Interaction of demand, technology and output

We view a solution of the basic economic problem of optimal area development as involving private and public investment at levels high enough to at least maintain the competitive position in the area's "export" industries and to provide for the growth of "export" and "local" markets at a rate equal to or greater than the increases in area labor productivity. Accordingly, we find highly useful recent formulations of production theory in which growth in output is represented as a function of both capital accumulation and technical progress and of labor.[5] We propose, however, to "embody" technical progress in the concept of increasing labor productivity while the incremental capital-output ratio is maintained at a given level. Thus, an increase in total physical capital would make possible an increase in output, but the impact of this increase on the required labor force would depend on the changing levels of labor productivity. For a given market demand, however, an imbalance in the levels of the two primary inputs would result in excess capacity or unemployment. When both labor and capital are in excess supply, an increase in area output is limited by the levels of market demand (in the industries that have available for their use the excess supplies of skilled labor, facilities and equipment).

We also propose to make local or area demand a function of area population and income; the latter is a function of the gross area output. Export demand, however, depends on an additional factor, namely, the share of the total national market accounted for by the industry in the given area. Whether or not the market share is increasing depends on relative production costs and accessibility to national markets.[6]

5/ Otto Eckstein. Capital theory and some theoretical problems in development planning. Papers and Proceedings. Am. Econ. Rev. May 1959. pp. 92-111.

Robert M. Solow. Technical progress, capital formation and economic growth. Papers and Proceedings. Am. Econ. Rev. May 1962. pp. 76-86.

6/ Harvey S. Perloff, Edgar S. Dunn, Jr., Eric E. Lampard and Richard F. Muth. Regions, Resources and Economic Growth. Johns Hopkins Press, Baltimore, 1960.

Reducing production costs and finding new market outlets involve both private and public investment, the latter providing the social overhead capital in such forms as education, highways, and research. Private investment involves two kinds of capital expenditures--replacement investment and induced investment. Replacement investment is financed by capital consumption allowances. However, for some industries with large incremental capital-output ratios and substantial growth in market demand, the supply of internal financing, i.e., income from capital consumption allowances and retained business earnings, may be inadequate to cover needed capital expenditures. For these industries, financing may be obtained from outside the area, provided the rate of return is adequate to attract the risk capital. In our model, the marginal productivity concept is "embodied" in the projected levels of market demand. The rate of return on capital in a growth industry presumably is adequate to induce capital movements into the industry.

Product and income flows

If all the capital and product flows or transactions that take place in an area economy were shown in terms of the major categories of transactors, at least three different systems of accounts would be needed: First, are the production transactions--those dealing with the disposition of goods and services produced and with the reimbursement of the primary inputs for services rendered; second, are the consumption transactions that involve the income payments to the primary inputs, including government, as well as the expenditure of the income on goods and services produced; third, are the capital transactions that account for the disposition of area savings and for the investment transactions. If the area economy is engaged in trade with other areas, then a fourth series of transactions can be identified, namely, those dealing with the balance of payments, including inter-area financial transfers. The income side of these transactions is represented by the simple flow diagram in fig. 1.

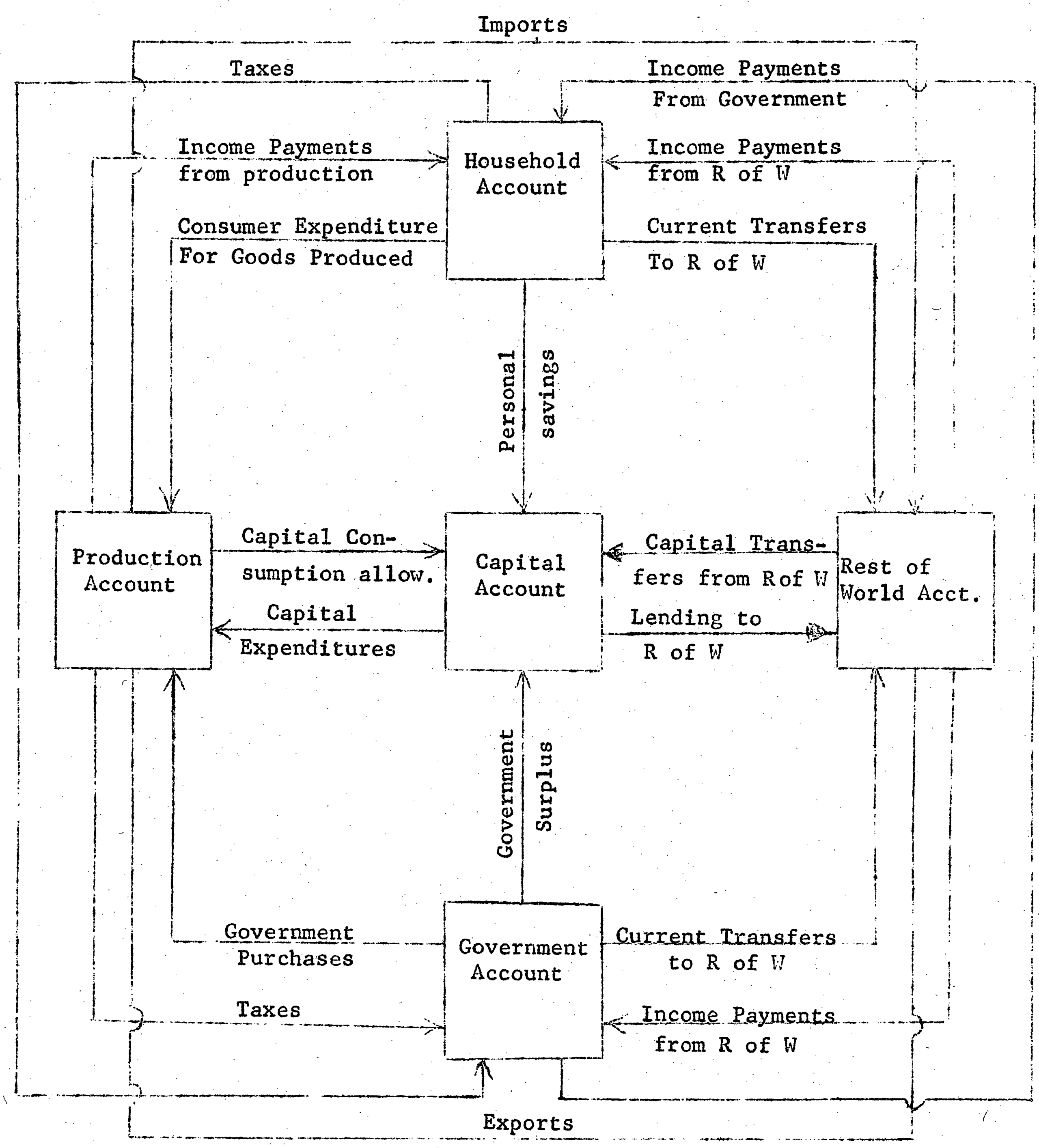


Fig. 1 Flow chart for an area economy

The area income flow chart is based on an application of national income theory to an area economy.[7] It is well recognized, however, that a system of area product and income accounts is substantially more difficult to prepare than a corresponding system of national accounts inasmuch as some of the information necessary to establish the situs of the transactor is lacking on an area basis.[8] Nonetheless, a consolidated system of area income and product accounts has been prepared that is based essentially on an expanded social accounting matrix; the latter includes four different current accounts, two capital accounts and an inter-area trade account.[9] In this social accounting matrix, 22 subsectors, including an input-output table and a capital-output table, have nonzero entries in the rows or columns that make up each of the seven major accounts.[10]

Interdependence of rural-urban relations

None of the 22 subsectors in the detailed social accounting table is differentiated on the basis of a rural-urban dichotomy. A spatial dimension still must be introduced that can account for the movement of people toward the major trade centers within a rural-urban complex.

7/ Richard Stone. Social accounts at the regional level. In: Regional Economic Planning, Walter Isard and John H. Cumberland (ed.), Organization for European Economic Cooperation, Paris. 1961, pp. 263-396.

Richard Stone and Alan Brown. A Computable Model of Economic Growth. Cambridge (England), Department of Applied Economics, 1962.

8/ Charles L. Leven. Regional income and product accounts: Construction and application. In: Design of Regional Accounts, Werner Hochwald, (ed.), Johns Hopkins Press, Baltimore, 1961, pp. 148-195.

9/ See, for example: National Bureau of Economic Research. The National Economic Accounts of the United States. U. S. Government Printing Office, Washington, D.C. 1958 p. 46.

10/ Except for the omission of a commodity sector, the expanded intersectoral transactions table is identical to the one discussed in Stone and Brown, op. cit. A further discussion of the 22 subsectors is found in the report by Maki, Suttor and Barnard.

Hierarchies of trade centers can be identified in many areas, particularly in the rural Midwest. As many as seven orders or functional categories of trade centers have been described by Philbrick, of which the "fourth order" trade center has been viewed as the central place for a multi-county "functional economic area". 11/ In Iowa, for example, a fourth-order trade center typically has a population of 20,000 or more; its clientele cover a half dozen or so counties with a total population in excess of 200,000. In the context of rural-urban development, the "central place" of a nodal area offers the major opportunities for economic growth. Both public and private investments are likely to be concentrated in the principal urban centers. We agree with Gray's analysis of economic development in the Southern Appalachian Region, namely that "an urban-industrial economy is emerging in which both the rural and urban areas have a common stake."12/

Our economic model thus involves elements of several theories of business growth in an area context. To show the social significance of private investment decisions, or the private business impacts of governmental decisions, a system of area income and product accounts has been incorporated into the area economic model. Also, intra-sectoral transactions within the social accounting framework are viewed taking place within a spatial structure of trade centers that include a focal area for rural-urban development.13/ The latter, finally, is achieved primarily through the private sector but in an economic and political environment that is conditioned partly by public policies and programs. The latter become the instrument or policy variables of area economic development in the programming model.

11/ Karl A. Fox. The study of interactions between agriculture and the nonfarm economy: local, regional and national. JFE, February, 1962.

12/ Alfred J. Gray. Local, state and regional planning. In: The Southern Appalachian Region: A Survey. Thomas R. Ford (ed.). University of Kentucky Press, Lexington. 1962. pp. 169-187.

13/ J. R. Boudeville. A survey of recent techniques for regional economic analysis. In: Regional Economic Planning, Walter Isard and John H. Cumberland (eds.), Organization for European Economic Cooperation, Paris. 1961. pp. 377-397.

Programming Model of
Rural-Urban Development

First, the area economic model is presented as a recursive system of equations. Next, data representing the Iowa economy in 1954 are used to implement the model and the computer procedures. Finally, the time paths of selected variables are generated over a 20-year period to illustrate the business impacts of specified policies dealing with public and private investments.

Recursive procedures

As an initial step in the preparation of the computer procedures, the system of equations representing the area economic model was rearranged as a recursive sequence.[14/] Altogether, 50 major equations were used to show the chain of events from capital consumption and labor utilization to the disposition of the business income among its claimants--households, government and business. Of the 50 major equations, 20 are disaggregated into as many as seven subequations--one for each of the seven interacting sectors in the abbreviated Iowa interindustry transactions table. Thus, a total of 170 different equations is represented in the computer model.

A brief description of the 50-equation system, as it appeared prior to its translation into detailed Fortran language for the IBM 7074 computer, is given now as an introduction to a later discussion of the data and the results.[15/] In the presentation of the individual equations, the following notation is employed:

V followed by alphabetic symbol denotes a vector of variables.

T followed by alphabetic symbol denotes a single variable--a total or aggregate concept.

V followed by a number denotes a vector of constants or parameters.

14/ R. H. Strotz and H. O. A. Wold. Recursive and nonrecursive systems: an attempt at synthesis. Econometrica. April, 1960.

15/ Donald D. McCracken. A Guide to Fortran. John Wiley and Sons, New York. 1961. International Business Machines. Reference Manual IBM 7070 Series Programming System: Fortran 1962.

A, B, C, D denote matrices.

S followed by a number denotes a scalar parameter.

Multiplication is indicated by a single asterisk (*) while a double asterisk (**) denotes an exponential process. Finally, the equations are numbered as they appear in the computer program as follows:[16/]

1. Business depreciation.
   VD (t) = B1 * VK (t)
   where, B1 is diagonal matrix of depreciation rates for the seven business sectors.

2. Net business investment.
   Where, B2 is diagonal matrix of capital-capacity output ratios and C1 is a diagonal matrix of equilibrium capacity utilization ratios for the seven business sectors.

   VI (t) = max { B2 * VXR (t-1) - C1 * (VK (t) + VK (t-1))/2 - VD (t).

3. Business sector labor force.
   VL (t) = C2 * VL (t-1) - VUL (t-1)
   where, C2 is a diagonal matrix in which the ith diagonal element is one plus the natural rate of growth of the labor force plus the equilibrium unemployment rate in the ith sector.

4. Population supported by the business sectors.
   VP (t) = B3 * VL(t)
   where, B3 is a diagonal matrix of population-employment ratios.

5. Total government payments to households.
   TYGW (t) = TT (t-1) * S1
   where, S1 is ratio of government payments to households to total tax payments.

6. Total government sector labor force.
   TLG (t) = (S2 ** (t-1)) * S3 * TYGW (t)
   where, S3 is the ratio of government labor force to government payments to households in the base year, and S2 is the annual rate of change in S3.

7. Population supported by government labor force.
   TPG (t) = S4 * TLG (t)
   where, S4 is the population-labor force ratio for government.

8. Total labor force.
   TL (t) = VL (t,1) +...+ VL (t,7) + TLG (t)

9. Total population
   TP (t) = VP (t,1) +...+ VP (t,7) + TPG (t)

16/ A triangular matrix can be formed by listing the dependent variables consecutively.

10. Household demand.
VH (t) = TP (t) * V1 + TPY (t-1) * V2
where, V1 is the expenditure-population coefficient and V2 is the expenditure-income coefficient.

11. Business capital formation.
VCF (t) = B4 * (VI (t) + VD (t))
where, B4 is a matrix in which the element in the ith row and jth column is the proportion of the jth sectors capital goods purchased from the ith sector.

12. Total capital goods imports.
TCFM (t) = D1 (1) * (VI (t,1) + VD (t,1)) +...+ D1 (7) * (VI (t,7) + VD (t,7))
where, D1 (j) = 1 - $\sum_{i}$ B4 (i,j).

13. Relative price level (exogenous)

$$\text{PRICE} = \frac{\text{Rest of World price level}}{\text{Area price level.}}$$

14. Export demand.
VED (t) = (B5 ** (t-1)) * V3 * PRICE
where, B5 is a diagonal matrix of autonomous growth ratesin export demands and V3 is export demand vector in base year.

15. Government purchases.
VG (t) = TT (t-1) * V4
where, V4 is ratio of government purchases to total tax payments.

16. Total final demand.
VZ (t) = VH (t) + VCF (t) + VED (t) + VG (t).

17. Output (to meet final demands)
VXD (t) = AI1 * VZ (t)
where, AI1 is the inverse of the (I-A) matrix.

18. Output (from full employment of capital)
VXK (t) = B21 * VK (t)
where, B21 is the inverse of the B2 matrix.

19. Output (from full employment of labor).
VXL (t) = (B6 ** (t-1)) * B7 * VL (t)
where, B6 is a diagonal matrix of annual rates of change in B7 and B7 is a diagonal matrix of output-labor ratios in the base year.

20. Realized output
VXR (t) = min (VXD (t), VXK (t), VXL (t)).

21. Deficit supply.
VDS (t) = VXD (t) - VXR (t).

22. Realized exports.
VRE (t) = VED (t) - VDS (t) * (VED (t)/ (VED (t) + VH (t))).

23. Realized household demand.
VRH (t) = VH (t) - VDS (t) * (VH (t)/ (VED (t) + VH (t))).

24. Unemployed capital (or "excess capacity").
VUK (t) = VK (t) - B2 * VXR (t).

25. Unemployed labor.
VUL (t) = VL (t) - B71 * (B61 ** (t-1)) * VXR (t)
where, B61 = $(B6)^{-1}$, B71 = $(B7)^{-1}$.

26. Business wages and salaries.
VYW (t) = B9 * VXR (t)
where, B9 is a diagonal matrix of payroll-output ratios.

27. Business (complementary) imports.
VCM (t) = C3 * VXR (t) * PRICE (t)
where, C3 is a diagonal matrix of import-output ratios.

28. Business value added.
VVA (t) = C4 * VXR (t)
where, C4 is a diagonal matrix of value added-output ratios.

29. Business tax payments.
VTX (t) = C5 * VXR (t)
where, C5 is a diagonal matrix of tax-output ratios.

30. Retained business earnings.
VRET (t) = C6 * VXR (t)
where, C6 is a diagonal matrix of retained earnings-output ratios.

31. Dividends and proprietorial income of unincorporated businesses.
VYDP (t) = VVA (t) - VYW (t) - VTX (t) - VRET (t) - VD (t).

32. Total dividends and proprietorial income of unincorporated businesses.
TYDP (t) = VYDP (t,1) +...+ VYDP (t,7).

33. Total business wages and salaries.
TYW (t) = VYW (t,1) +...+ VYW (t,7).

34. Total personal income.
TPY (t) = TYDP (t) + TYW (t) + TYGW (t).

35. Total household (competitive) imports.
THM (t) = S5 * TPY (t-1)
where, S5 is the ratio of total household imports to total personal income.

36. Total business (complementary) imports.
TCM (t) = VCM (t,1) +...+ VCM (t,7).

37. Total government imports.
TGM (t) = S6 * TT (t-1)
where, S6 is the ratio of total government imports to total tax payments.

38. Total imports.
TM (t) = THM (t) + TCM (t) + TCFM (t) + TGM (t).

39. Total exports.
TRE (t) = VRE (t,1) +...+ VRE (t,7).

40. Balance of trade.
BALTR (t) = TRE (t) - TM (t).

41. Total household tax payments.
THT (t) = S7 * TPY (t-1)
where, S7 is the ratio of total household tax payments to total personal income.

42. Total household (domestic) purchases.
THDP (t) = VRH (t,1) +...+ VRH (t,7).

43. Personal savings.
PS (t) = TPY (t) - THDP (t) - THM (t) - THT (t).

44. Total business tax payments.
TTX (t) = VTX (t,1) +...+ VTX (t,7).

45. Total tax payments.
TT (t) = TTX (t) + THT (t).

46. Total intergovernmental transfers.
TIGT (t) = S8 * TT (t-1)
where, S8 is the ratio of total intergovernmental transfers to total tax payments.

47. Total government purchases of domestic or area produced goods.
TG (t) = VG (t,1) +...+ VG (t,7).

48. Total domestic or area production of capital goods.
TCF (t) = VCF (t,1) +...+ VCF (t,7).

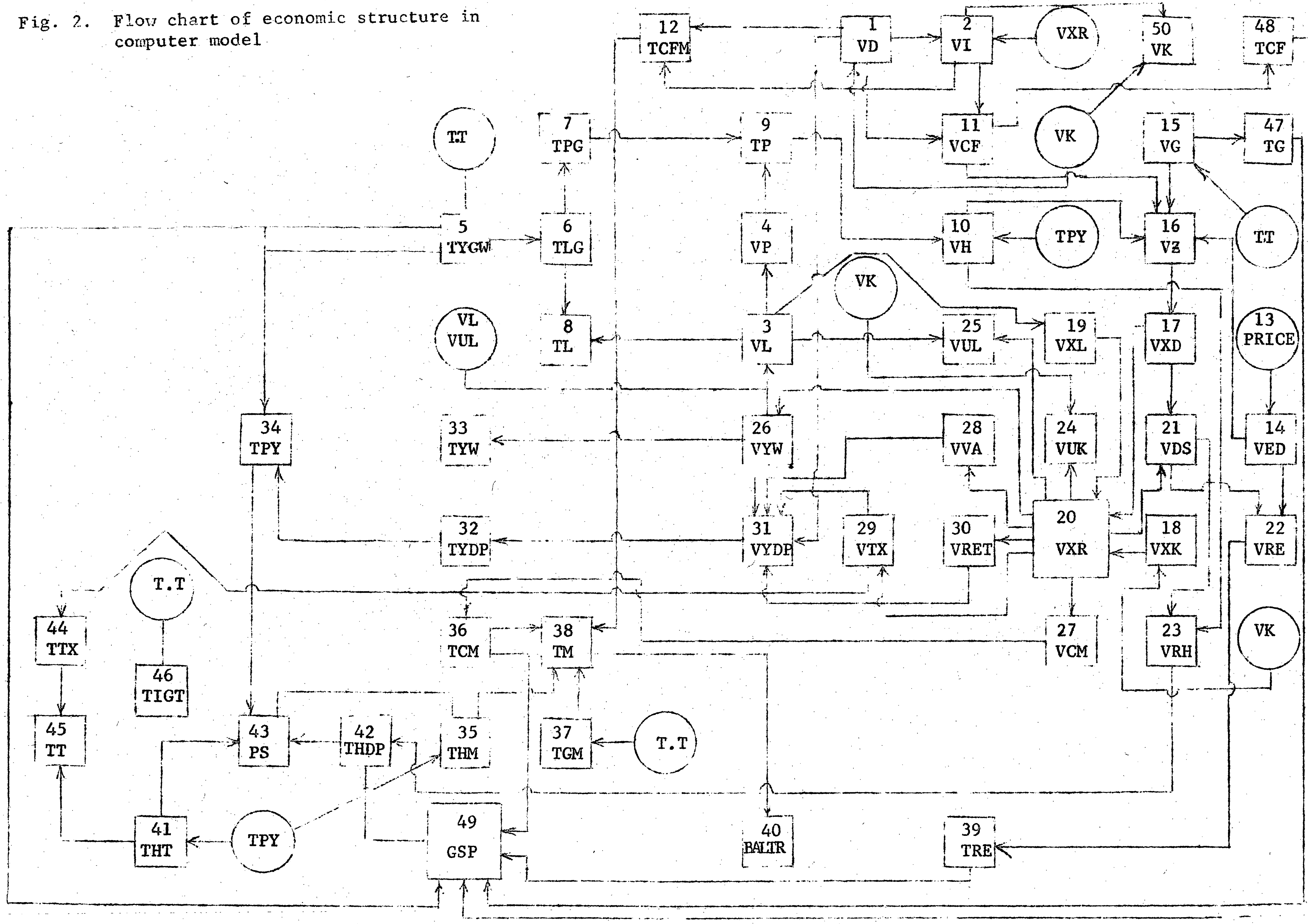
49. Gross state or area product.
GSP (t) = THDP (t) + TG (t) + TYGW (t) + TCF (t) + TRE (t) - TCM (t).

50. Total accumulated capital (physical assets).
VK (t+1) = VK (t) + VI (t).

A flow diagram of the economic structure depicted by the computer model is presented in fig. 2. In this diagram the endogenous variables are represented by the rectangles which are interconnected sequentially, as shown by the directional lines.

Finally, in programming, the outputs of year (t) become the inputs of year (t+1), for example, as illustrated by equation 50. The diagonal matrices of labor productivity and growth in export demand are based on several exogenous factors, but the estimated effects of these factors on the area economy have been incorporated into the specified annual rates of change. Similarly, the relative price

Fig. 2. Flow chart of economic structure in computer model



levels are tied to expected changed in the area's competitive position in its export markets. Thus, the outputs of year (t) that become the inputs of year (t+1) are confined to the several variables (vectors) included in equations1, 2, 3, 5, 10, 15, 18, 24, 35, 37, 41, 46, and 50. These lagged variables are: physical assets (VK), realized output (VXR), business labor force (VL), unemployed labor (VUL), total tax payments (TT), total personal income (TPY) and relative prices. Forty-nine different endogenous variables, six lagged endogenous variables and one exogenous variable are represented, therefore, in the algebraic formulation of the computer model.

Empirical results

We turn now to the 1954 Iowa interindustry transactions table (table 1). It should be noted that government receipts, capital consumption and imports are not balanced with the corresponding final demands (i.e., government purchases, capital formation and exports, respectively). Among the final demands listed in table 1, the estimate of exports is substantially larger than the expected level of exports because of the inclusion of federal government purchases in the export column. Also, it should be noted that 66 percent of industrial sales and 47 percent of sales to households in 1954 were made to farm or farm-related consumers.[17/] When viewed as a basic economic activity, the agribusiness complex in Iowa still accounts for a major part of the total value of sales and purchases and also of the gross state product.

The inverse of the (I-A) matrix, which is represented as AI1 in equation 17 is based on the input-output data in table 1. In addition, the capital accounts vector has been expanded (see the B4 matrix in equation 11) to include each of the seven Iowa sectors purchasing the capital goods produced in Iowa. However, of the 15 diagonal matrices cited in equations 1 to 50, only the coefficients for seven

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17/ Wilbur R. Maki. Prospects of Iowa's People and Economy. Part I: Agricultural Change and Economic Growth. Iowa College-Community Research Center. Unpublished report 1963.

Table 1. Iowa interindustry transactions, 1954.

Producing Sectors	Intermediate purchases							Final demands				
	Agriculture		Manufacturing			Services						
	Livestock	Crops and other	Food	Farm machinery	Other mfg.	Regulated industries	Trade, construction and other services	Household expenditures	Government purchases	Private capital formation	Exports	Gross output
	1	2	3	4	5	6	7	8	9	10	11	12
					($1,000)							
Agriculture:												
Livestock	211,804	--	1,094,638	--	221	80	5,150	50,363	2,467	--	736,035	2,100,758
Crops & other	824,842	144,114	123,054	--	59,155	446	2,760	25,021	795	1,024	171,478	1,352,689
Manufacturing:												
Food	129,658	9,337	176,978	--	15,156	2,415	20,916	524,746	6,539	11	1,043,300	1,929,056
Farm machinery	1,409	3,830	26	16,041	4,450	124	674	--	2,386	103,427	103,132	235,499
Other manufacturing	10,482	47,475	50,061	48,329	293,203	29,686	174,428	290,419	86,118	210,064	3,928	1,244,193
Services:												
Regulated industries	69,950	27,153	46,902	5,949	42,789	48,934	153,172	254,794	30,879	16,267	81,886	778,675
Trade, construction and other services	97,993	238,275	46,729	8,084	49,938	75,290	490,627	1,921,720	299,510	177,833	199,919	3,605,918
Distribution of Business Income:												
Households	434,601	701,719	225,035	76,492	525,031	276,014	1,926,889	--	428,197	--	--	4,493,978
Government	40,959	56,648	26,463	9,632	54,231	99,624	416,435	398,881	156,554	--	--	1,259,427
Capital consumption	23,510	78,567	58,366	7,879	94,423	184,586	248,893	380,844 1/	--	--	--	1,077,068
Imports	255,550	45,571	80,804	63,093	205,596	61,476	165,974	647,190	89,127	230,572	--	1,844,953
Gross outlay	2,100,758	1,352,689	1,929,056	235,499	1,244,193	778,675	3,605,918	4,493,978	1,102,572	739,198	2,339,678	19,922,214

1/ Personal saving of households

of these matrices are summarized in table 2. Of particular interest in this study are the large differences in labor productivity and market demand trends in agriculture. The former greatly exceed the latter so that approximately 98,000 farmers are displaced by farm consolidation and mechanization over the 20-year period. On the other hand, 158,000 new jobs are expected to develop in the service industries (sector 7), which will offer some of the displaced farmers employment in off-farm occupations. Presently, however, the occupational distribution of the Iowa labor force is not included in the recursive system of equations. Consequently, the level of migration into and out of Iowa is not derived as one of the factors in rural-urban development.

Finally, a consolidated Iowa social accounting matrix for 1954 (which unlike table 1, includes federal government receipts and expenditures in the Rest of World Account) is shown in table 3. The variables in this table have been generated by the computer model for the 1954-1974 period.

Programming results

To briefly illustrate the nature of the programming results, two investment series, an income series and a gross state product series are presented for the 20-year period from 1954 to 1974 (see figures 3 and 4). Because of the logical structure of the model--particularly the relationship between current expenditures or consumption and lagged income or output, investment cycles of varying amplitude and duration are introduced into the computer sequences. Farm machinery manufacturers, for example, are shown as having a rather stable pattern of investment. In contrast, other manufacturing has more investment instability as a result of output fluctuations and over-investment in the latter part of the 20-year period. Also, the technical interdependencies among the manufacturing, agricultural and service sectors modify the amplification phenomenon in the investment processes for particular industries.

Table 2. Selected series of coefficients for specified diagonal matrices in computer model of Iowa economy, 1954.

Sector	Depreciation rates a/ B1	Capital-capacity output ratio b/ B2	Labor productivity trend c/ B6	Labor force participation rate d/ $(B4)^{-1}$	Export demand trend e/ B5	Output labor ratio f/ B7	Value Added-output ratio g/ C4
Agriculture:							
Livestock	0.0249	0.4500	1.0470	0.3727	1.0168	14.3620	0.2376
Crops and other	0.0742	0.7831	1.0570	0.3727	1.0197	11.2980	0.6187
Manufacturing:							
Food	0.1081	0.2221	1.0260	0.4037	1.0287	37.0420	0.1606
Farm machinery	0.0575	0.5188	1.0400	0.4037	1.0477	14.5850	0.3992
Other	0.1031	0.5804	1.0340	0.4037	1.0434	12.4230	0.4612
Services:							
Regulated industries	0.1423	1.6300	1.0430	0.4037	1.0363	11.2650	0.7195
Other	0.0234	2.8395	1.0140	0.4037	1.0300	8.0690	0.7189

a/ Depreciation per dollar of capital based on calculated values of capital stocks and capital consumption per unit of output.

b/ Capital per dollar of output based on data in: S. Kuznets, Capital in the American Economy, National Bureau of Economic Research, Princeton, 1961; and W. Leontief, "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis", Review of Economics and Statistics, Nov., 1956.

c/ Annual rate of growth in output per worker based on data prepared by the National Planning Association.

d/ Ratio of labor force to population based on data in: Maki, Suttor and Barnard, op. cit.

e/ Annual rate of growth in exports based on projected U.S. production and given Iowa market shares.

f/ Output per worker in thousands of dollars.

g/ Value added per dollar of output.

Table 3. Social accounting matrix for Iowa, 1954 [a]

Incomings \ Outgoings	Production Account	Consumption Account	State and Local Government Account	Capital Account	Rest of World [b] Account	All Accounts
			($1,000)			
Production Account	0	3,714,253	544,224	739,198	572,201	5,569,876
Consumption Account	4,169,660	0	0	0	324,318	4,493,978
State and Local Government Account	475,941	20,881	0	0	48,815	545,637
Capital Account	696,224	380,844	0	0	0	1,077,068
Rest of World [b] Account	228,051	378,000	1,413	337,870	0	945,334
All Accounts	5,569,876	4,493,978	545,637	1,077,068	945,334	- -

a/ Outgoings and ingoings are with reference to the directional flows depicted in fig. 1.

b/ Including federal government.

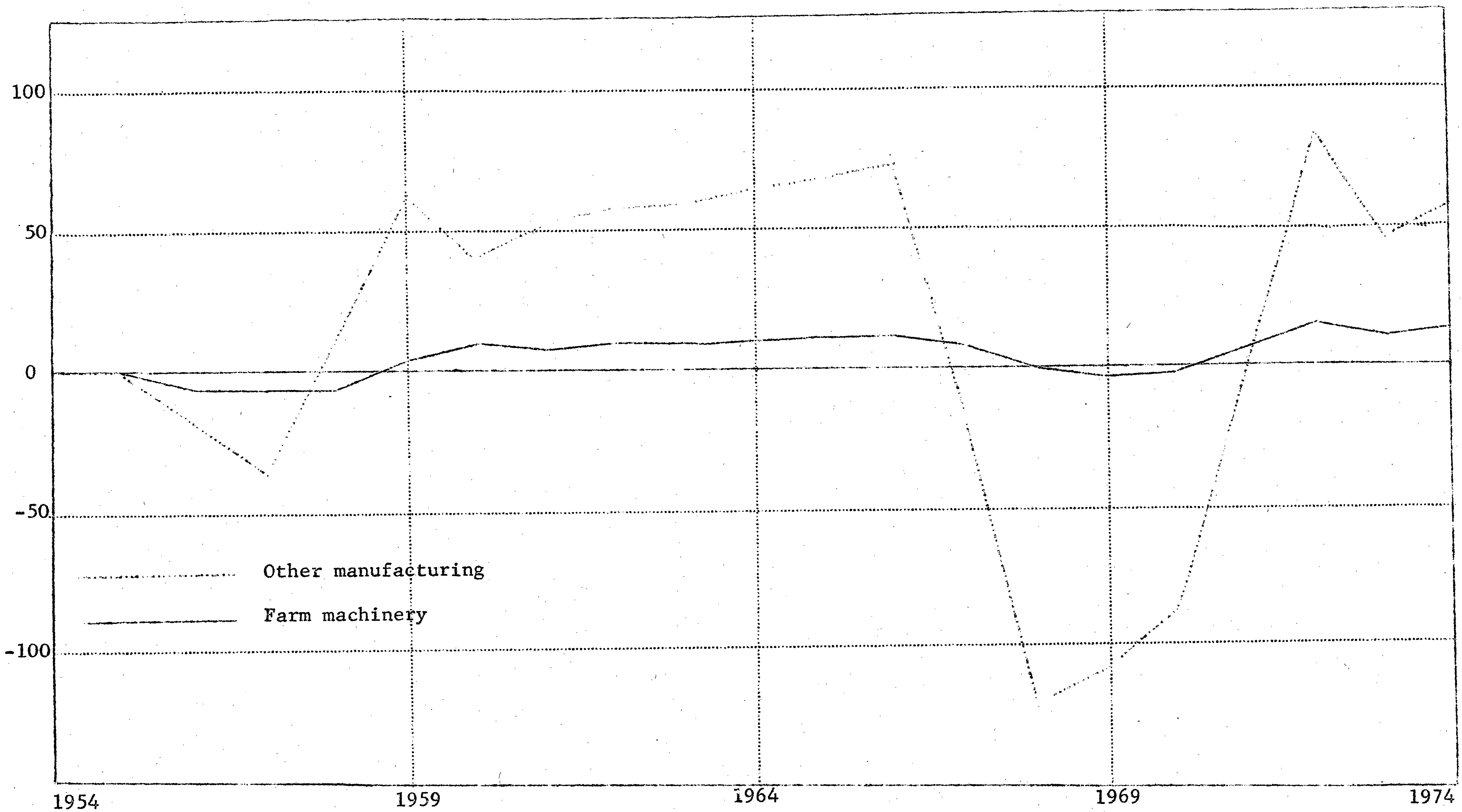

Fig. 3. Investment in farm machinery and other manufacturing, Iowa, 1954-1974.[a]

a/ In the original model the lower limit on the net investment level was the negative of depreciation. However, the revised model will have a lower limit of zero to further constrainthe fluctuations in net investment.

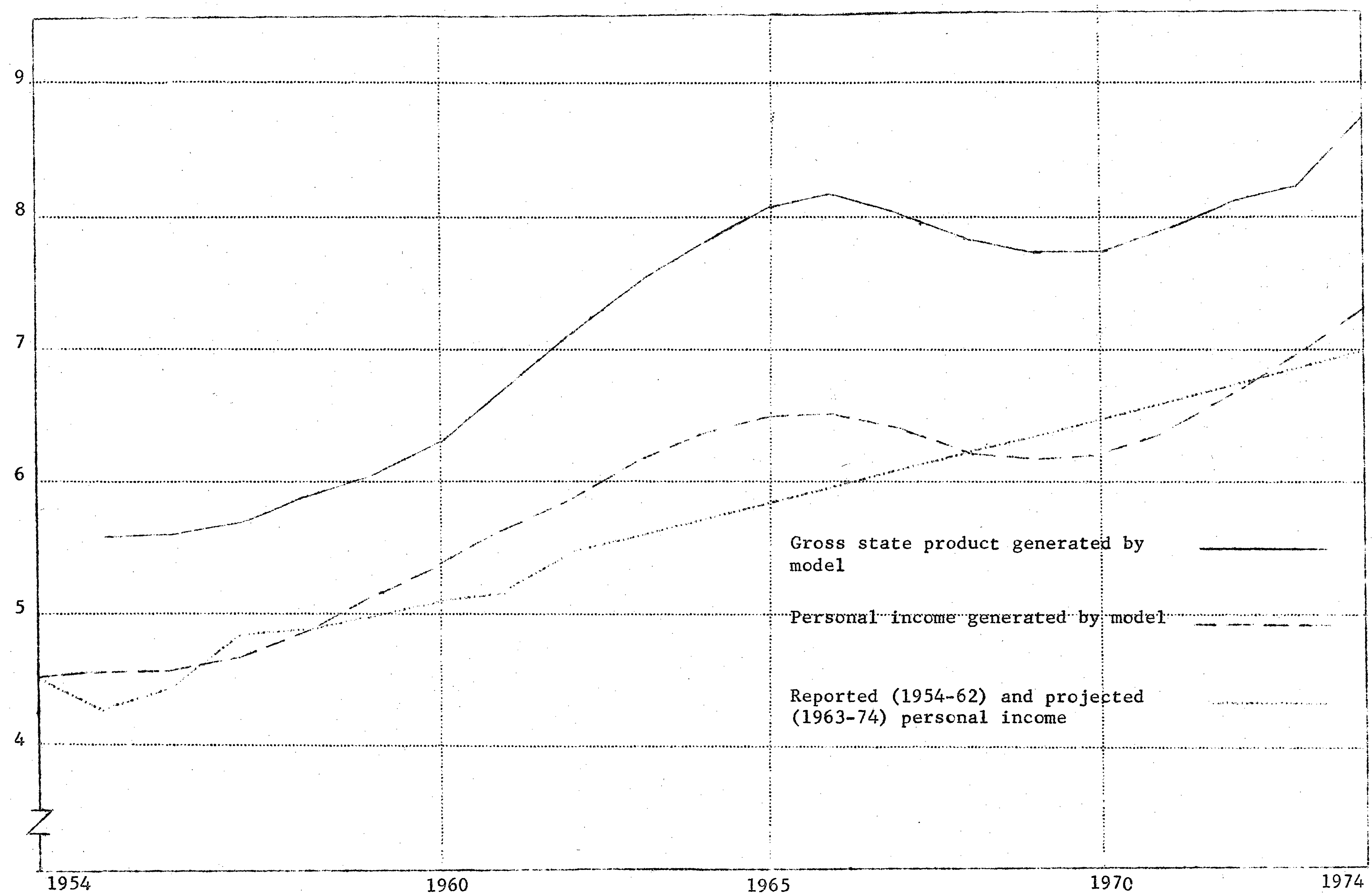

Fig. 4. Gross state product and personal income, Iowa, 1954-1974.

The predictive accuracy of the annual estimates generated by the computer model is less than satisfactory because of the excessive fluctuations in most of the series. Over a period of years, however, the model predicts reasonably well, as suggested by the estimates of total personal income in fig. 4. The computer results and the reported 1954-1962 income levels (which are extended to 1974 on a linear trend basis) correspond quite closely, except for cyclical phenomenon.

The logical structure of the area economic model is being modified to correct the larger-than-expected year-to-year fluctuations. In addition, the seven-sector breakdown is being expanded into a more detailed representation of the Iowa economy that includes education, construction and several other services as separate sectors. A more detailed breakdown of the service sectors would involve unique rates of increase in market demands and labor productivity and, accordingly, somewhat higher levels of employment.

Finally, the major aggregate economic series are listed again in table 4 along with the terminal year estimates obtained from the simulation runs. In addition, the annual rates of growth of each of the five major Iowa accounts are presented for comparison with the data shown earlier in table 2. According to the data in table 4, a 1.8 percent annual growth rate in the capital accounts (which is based on the accumulated capital accounts for the 1954-1974 period) is consistent with a 2.4 percent increase, compounded annually, in the production accounts. The rates of growth in the two accounts are not equal because of different rates of capacity utilization in 1954 and 1974 and because of the changing composition of the state's output.

Applications of Programming in Area Economic Analysis and Prognosis

Even at their present stage of development, the area economic model and programming procedures have been useful in ascertaining the year-to-year effects of various rates of increase in labor productivity and market demand. We have noted,

Table 4. Social accounting matrix for Iowa, 1974. a/

Outgoings / Incomings	Production Account	Consumption Account	State and Local Government Account	Capital Account	Rest of World Account b/	Total Accounts	
						Total	Annual Rate of Increase c/
			($1,000)				
Production Account	0	4,953,079	945,316	2,201,654	780,165	8,880,214	1.0236
Consumption Account	6,720,373	0	0	0	522,714	7,243,087	1.0242
State and Local Government Account	826,709	36,270	0	0	84,792	947,771	1.0280
Capital Account	1,040,713	1,661,472	0	0	0	2,702,185	1.0471 d/
Rest of World Account a/	292,419	592,266	2,455	500,531	0	1,387,671	1.0194
All Accounts	8,880,214	7,243,087	947,771	2,702,185	1,387,671	- -	- -

a/ Based on assumption of "low" increase in out-of-state shipments.

b/ Including federal government.

c/ Relative rate compounded annually.

d/ Annual rate of increase in investment. The annual rate of increase in capital stock was 1.0182. The two estimates differ because of the projected high level of investment in 1974 in relation to the 1954-74 average investment level. The estimated growth in capital stock compares with the estimated 1.0184 annual growth rate for capital inputs in the National economy over the 1929-58 period. See: Edward F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us, committee for Economic Development, Washington, D.C., 1962, p. 141

for example, that the estimated growth in the market demand for services is not consistent with the estimated growth in personal income and the estimated increase in labor productivity. Total employment and total population, therefore, are somewhat lower than expected on the basis of the additional evidence generated by the model. Similarly, the area implications of parametric changes in governmental expenditures and receipts can be explored experimentally in relation to corresponding changes in the distribution of area business incomes, the productivity of area resources, and the market shares of an area's export industries.

Other applications of the model will require modification of its logical structure and empirical content. For example, additional detail is needed in the governmental sectors, as suggested earlier, to provide data that will show the effects of area economic growth on particular revenue sources and expenditures. A spatial dimension also can be introduced through an industrial and population breakdown on the basis of residence or urbanization. Finally, the model and programming procedures can be confined to a sub-state functional economic area, or even a particular industry at the state level of aggregation, as a basis for policy analysis and prognosis.

Further modifications of the logical structure and empirical content of the computer model may occur through the inclusion of productivity and preference functions. The allocation of income between savings and consumption, for example, would be achieved in the context of the two additional constraints--the rate of return on incremental capital expenditures and the social or private preference functions of the decision makers engaged in the allocation of current income between consumption and investment. These changes, of course, would make the simulation model more nearly like an optimizing model.