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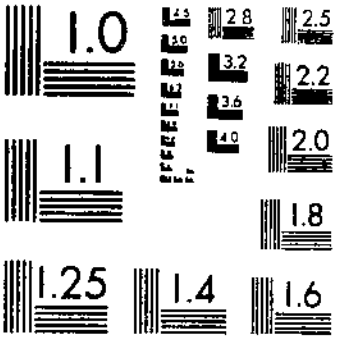

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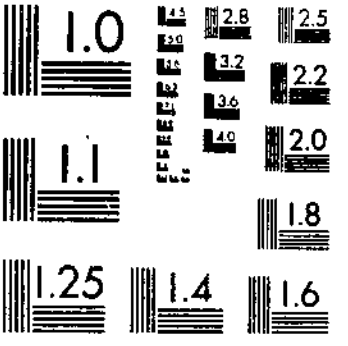

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APPLICATION OF ACTIVITY ANALYSIS TO REGIONAL DEVELOPMENT PLANNING:

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A Case Study of Economic Planning in Rural South Central Kentucky

esource Development Economics Division Economic Research Service
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CONTENTS

	Page
HIGHLIGHTS	vi
I INTRODUCTION	1
II THE GLASGOW TRADE AREA	6
Demographic Characteristics	6
Agriculture in the Region	7
Labor Force and Employment Characteristics	10
III GENERAL FORMULATION OF THE MODEL FOR A REGIONAL DEVELOPMENT PROGRAM	13
Goals and Time Span of the Development Program	13
Description of the Formal Model	14
Functioning of the Model	15
IV MATHEMATICAL FORMULATION OF THE REGIONAL DEVELOPMENT PROGRAM MODEL	19
Notation	19
Treatment of Exports	21
Treatment of Technological Change	22
The Balance Equations	22
The Objective Function	26
V APPLICATION OF THE MODEL TO THE GLASGOW TRADE AREA	27
Construction of the Activity Vectors	27
Sources of Data for Activity Vectors Construction	30
Targets and Constraints	31
VI RESULTS OF COMPUTER RUNS	45
Basic Solution R013-1	46
Comparison of Foreign Exchange Balances and Industrial Composition of the 7 Computer Runs	49
VII GENERAL EVALUATION	55
Evaluation of Prospects for Development Program in Glasgow Trade Area	55
Implications for the General Application of the Activity Analysis Planning Model	57
Suggestions for Improving the Data and Methodology	59

LIST OF TECHNICAL DATA SOURCES USED IN CONSTRUCTING THE ACTIVITY VECTORS 61

LITERATURE CITED 79

APPENDIX A. --ACTIVITY VECTORS IN THE REGIONAL DEVELOPMENT MODEL: DESCRIPTION AND SOURCES 80

APPENDIX B. --ACTIVITY AND COMMODITY INDEX . 86

HIGHLIGHTS

This report is concerned with the development and utilization of an econometric model for planning economic development in small rural areas. The planning model was developed for a 5-county area in south central Kentucky (Glasgow trade area) selected as a case study area.

The model is a highly disaggregated form of linear programming. It was designed to determine: (1) The amount of outside financing needed to meet the increase in income and consumption adopted as the targets for the development plan; (2) the mix of new manufacturing and agricultural activities that will cost the least in outside financing; (3) the techniques of production to employ where alternative techniques are available; (4) the amount of technological change required in existing economic sectors, especially agriculture; (5) the amount of labor, by level of skill, required for the plan, and any shortage or surplus in the local labor force; and (6) the amount of local capital formation required.

The model contains a pricing mechanism that tends to make the optimal solution conform to a competitive solution for the area. This is done by including activities in the solution that could be profitably established in the case study area under conditions specified for the model. The optimal solution is made to conform to the competitive solution by simulating the trade pattern of a free economy. The inclusion of the trade element in the model also allows it to specify a foreign exchange requirement for the area.

The methodology utilized in this report permits an internal check as to whether the proposed development area is a satisfactory size for analysis and planning. Such a check is provided by the derivation of a labor balance account, which shows the required in and out flow of various types of skills necessary to implement a particular economic development plan. Also, if it is established that an area is capable of sustained growth, the methodology indicates the direction in which the area's economy could move in order to achieve specified income goals with minimum capital requirements.

The methodology employed in this study adds an important feature to the market mechanism in that it achieves a simultaneous solution, thereby taking into account the external economies that result from simultaneous expansion of sources of material supply, markets, supporting public and private services, and labor supply. Thus, it suggests that an important policy instrument for regional development planning is coordination of both public and private investment decisions in order to assure that there will be simultaneous investments in interrelated and mutually supporting sectors. Also, the model provides a means of testing the effects of alternative policies on a solution.

The model is especially useful for planning in small, low-income, rural regions having the following characteristics: (1) The region is not expected to become capital goods producer, rather, most capital goods required for industrial expansion will have to be imported; (2) agriculture occupies a dominant position in the region's economy; and (3) an exceptionally large proportion of the region's labor force is unskilled.

The model contains features not contained in any of the current programming models used in development planning. Some of the more important of these features are: (1) A highly disaggregated foreign trade sector that permits competitive comparisons between local and foreign industries; (2) the endogenous inclusion in the model of technological change; and (3) the detailed analyses of labor demand and supply, permitting the construction of realistic labor balances.

The outside capital required for a development program for the Glasgow, Ky., trade area is not excessive. In order to implement a program designed to raise incomes in the area by $48 million, equivalent to a per capita rate of 5.6 percent per annum, fixed investment by outside agencies (i.e., public and private) of $37 million is required for the total 10-year development program. In addition, the outside investment is expected to bring about local capital formation of $71 million. These relationships are acceptable. On the other hand, the annual deficit in the foreign exchange balance on current account for goods and services of about $15 million is high. The results of the program indicate that self-sustaining growth has not been achieved by the end of the 10th year. It was found, however, that the amount of income created and the net export balance in the regional development program are affected by the constraints on exports.

It is possible that the study area can achieve a self-sustaining growth rate less than the original goal of 5.6 percent, but considerably above what it is presently experiencing. Also, it may take such an area more than 10 years to reach self-sustained growth.

There is a significant scarcity of persons available for managerial and skilled positions in many areas. Unless the region in which the development program is to be implemented can import a large number of persons in these categories, or unless the area encompassed by the program is expanded to include a larger, more diversified labor force, it will not be possible to carry out the program.

Varying some of the major parameters, such as wage rates, did not significantly alter the composition of the optimum program. This stability factor indicates that the general composition of the program is focused in the right direction and tends to increase confidence in the results of the program. With the composition of the program pretty well established, the basic plan is set forth, and program

oriented agencies can proceed in an organized manner to develop the detailed follow-up studies that are required for the formulation of development programs in specific areas.

Since the model is quite flexible, resources which act as restraints on development prospects can be identified and the effects of changes in these resources evaluated. Planners need such information. It allows them to redirect the development program and to prevent gross planning errors. In addition to providing a development in an aggregate sense for an area as a whole, the model provides guides to investment decisions by individual entrepreneurs.

Application of Activity Analysis to Regional Development Planning

A Case Study of Economic Planning in Rural South Central Kentucky

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I INTRODUCTION

The problems of chronic high rates of unemployment and relatively low family incomes in many rural areas of the United States are by no means recent phenomena. The problems have received considerable study and discussion over the past several decades. Only in recent years, however, have comprehensive efforts been made to analyze the low-income problem for its effects on the economic well-being of the people involved and for the differential rates of economic growth of these areas and the Nation. Millions of people are known to be living in poverty, and billions of man-hours of productive energy are wasted each year through unemployment and underemployment. Because of the inability of the individuals themselves to cope with this situation, Federal, State, and local governments have recently begun to focus attention on ways and means of ameliorating these conditions in low-income areas.

Government agencies which are in a position to formulate active and comprehensive development programs need guides for developing practical methods of improving incomes and levels of living through more efficient use of all available resources. Because research in small-area development is relatively new, there is a lack of proven methodology. Planners are not able to determine whether or not a small-area economy is viable, and whether a particular area has sufficient size and resources to accomplish the needed development. Research, then, is a necessary first step to any area development program.

One way for ameliorating underemployment, unemployment, and low incomes of farm families and other residents of depressed rural areas is additional capital investments in new industries, public facilities, and both private and public development of higher levels of skills and education among the labor force in the particular area. But those in charge of planning area development programs have no way of knowing: (1) Whether the area has development potential; (2) the types and sizes of investments that are economically suitable for low-income areas having different resources; and (3) the effects of differing amounts of investment associated with various proposed programs on incomes and employment in small-area economies.

In particular, analytical methods and procedures are needed to estimate the effects on income and employment that can be expected in low-income rural areas from additional public and private investments in the area. The primary purpose of the research reported here was to develop a planning model that, with adaptati s o varying local conditions, will be suitable for appraising the overall potentials of additional industrial, commercial, and other forms of public and private capital investment in such areas. In addition, the model could direct the follow-up studies that are required for formulating a comprehensive economic development program of a specific area.

It is important, therefore, that an analytical method which would serve in this capacity meet at least four basic criteria. First, many factors are associated with and influence the incomes of individuals and families. Low incomes in rural areas often result from low productivity in agriculture and inadequate opportunities for members of farm families to earn incomes outside agriculture and rural based agribusinesses. Low incomes may also be attributed to the settlement pattern of an area, to technological advances which have benefited some areas relative to others, or to a more rapid capital formation in some areas than in others. These causal factors are certainly interrelated, and each of them is responsible to some extent for the conditions in low-income rural areas. Because the combination of factors that cause low incomes vary among regions, no one standard treatment can be prescribed for all situations. Therefore, one criterion of this method of analysis is that it be applicable to a wide variety of economic conditions.

Second, economic growth and development of an area is certainly a function of progress made in each individual sector in the area. As new technologies are advanced, each sector has its own internal adjustment problems. But if growth of the entire area is to be considered, interindustry relationships must be brought into proper focus. In recent years, more than ever before, the agricultural sector is being recognized as only one of many interacting sectors of a regional

or national economy. Therefore, another criterion of an analytical method is that it must embrace all sectors of the economy of an area.

Third, consideration must be given to interarea as well as interindustry relationships. A fundamental difficulty with regional planning is that a region is essentially an open economy permitting a free flow of capital, labor, and commodities among areas of the Nation. Any plan that attempts to alter the existing pattern of these flows is battling a powerful market mechanism. Furthermore, a free enterprise system provides few tools with which to wage this battle. The model developed here contains a pricing mechanism that tends to make the optimal solution conform to a competitive solution for the area by simulating the trade pattern of a free economy.

There are activities in the model to export from the area and to import to the area all producible commodities at realistic market prices. Thus, a production activity is included in the solution only if it can sell profitably in the local market at a price less than the import price, or it can export only if it can sell in outside markets profitably at less than the delivered price from competitive areas.

The trade element in the model also allows the model to specify a foreign exchange requirement for the area, i.e., the amount of funds which must be provided from outside the area to promote a given development plan.

The fourth criterion of the model is that it should serve to answer two major questions from a public policy point of view. First, is the task of raising incomes in an underdeveloped region worth undertaking in terms of economic costs and benefits? The solution to the model provides information necessary to compute the ratio of investment to income. By comparing this ratio for one area with those computed for other areas, or that used as a standard for acceptable return on investment, it is possibly to determine the economic feasibility of the suggested development program. In addition, the methodology used in this analysis permits an internal check on whether the size of the region is satisfactory for analytical and planning purposes. Such a check is provided by the derivation of a labor balance account, which shows the required in and out flow of labor of various types and skills necessary to implement a particular economic development plan. An excessive in-flow relative to local labor supplies indicates either an overambitious program, or a poorly delineated region.

Second, if the answer to the first question is yes, what is the most efficient way of doing this, given the present conditions? In other words, if it is established that an area is capable of sustained growth, in what direction should the economy move in order to achieve specified income goals with minimum capital requirements.

This report describes the development of a methodology which fully meets the criteria presented above for any low-income rural region. In addition, it specifically provides means for determining:

(1) The amount of outside financing needed to meet the increase in income and consumption adopted as the targets for the development plan.

(2) The mix of new manufacturing and agricultural activities that will cost the least in outside financing.

(3) The techniques of production to employ where alternative techniques are available.

(4) The amount of technological change required in existing economic sectors, especially agriculture.

(5) The amount of labor by level of skill required for the plan, and any shortage or surplus in the local labor force.

(6) The amount of local capital formation required.

(7) The variations in the cost and content of the plan that result from varying the assumptions concerning out-migration.

The methodology presented below adds an important feature to the market mechanism in that it achieves a simultaneous solution, thereby taking into account the external economies that result from simultaneous expansion of sources of material supply, markets, supporting public and private services, and labor supply. Thus, the methodology suggests that an important policy instrument for regional development planning is coordination of both public and private investment decisions in order to assure that there will be simultaneous investments in interrelated and mutually supporting sectors.

In addition, the methodology provides a means of testing the effects of alternative policies or alternative projections on a solution. In other words, it provides policymakers with an opportunity to observe the effects upon the final solution of altering certain parameters or constraints.

The methodology employed must "seek an equilibrium solution which simultaneously allocates investment resources among various uses" (A2).[1] Activity analysis or mathematical programming is equipped to handle this type of problem. The purpose of this study is to apply an activity analysis model in the form of linear programming to optimal development programs for small regions. The model as applied here has been

[1] Underscored numbers in parentheses refer to items in List of Technical Data Sources, p. 61; underscored letters refer to items in Literature Cited, p. 79.

particularly adapted for planning in small, low-income, rural regions with three special characteristics: (1) The areas are not expected to become capital goods producers; rather, most capital goods required for industrial expansion will have to be imported; (2) agriculture occupies a dominant position in the region's economy; and (3) an exceptionally large proportion of the region's labor forces are unskilled.

The model developed in the report contains features that are not found in any of the presently existing programming models. Three important features are: (1) A highly disaggregated foreign trade sector that permits competitive comparisons between local and foreign industries; (2) the endogenous inclusion in the model of technological change; and (3) the detailed analysis of labor demand and supply, permitting the construction of realistic labor balances. These features make this model useful for planning predominantly rural areas.

In order to assure realism, the methodology was developed for a particular low-income rural area in south central Kentucky, the Glasgow trade area. A brief discussion of the region follows.

II THE GLASGOW TRADE AREA, 1960

Demographic Characteristics

In 1960, the population of the 5 counties of Barron, Cumberland, Hart, Metcalfe, and Monroe, Ky., was 70,423. This was an 8.2 percent decline from the 1950 population of 76,712.

The region is predominantly rural. It has only one city with a population large enough to rank it as an urban center (2,500 or more population). This city is Glasgow, the central city of the region; in 1960, it had a population of 10,069. From 1950 to 1960, Glasgow's population increased 43 percent, the only bright spot in an area of generally declining population.

The decline in population in the area from 1950 to 1960 resulted from extensive out-migration. An estimated 25 percent of the potential 1960 population left the area. Since the migrants were concentrated in the age group under 40, the population remaining in the area became relatively older. This older population is important in determining the labor force available for the development program. The educational attainment of the population is important for determining the proportion of the local labor force that can be expected to fill skilled positions in a regional development plan. In 1960, the educational status of the people in the Glasgow trade area was considerably below that of Kentucky. The proportion of the population having completed 4 years of high school for the study area and for Kentucky are presented in table 1.

Table 1.--Proportion of the population having completed 4 years of high school, by sex and age group, 5-county study area and Kentucky, 1960

Age group	5-county study area		Kentucky	
	Male	Female	Male	Female
	Percent	Percent	Percent	Percent
14-24.....	[1] 20.2	[1] 28.1	24.4	33.6
25 and over.....	8.2	11.1	14.3	18.7

[1] Estimated.

Source: U.S. Census of Population (132, 1960, Kentucky Ser. C).

The data on the percentage of population enrolled in school in 1960, by age, show that the future proportion of high school graduates can also be expected to be lower in the 5-county area than in Kentucky (table 2).

Table 2.--Proportion of population, 5-24 years of age enrolled in school in 1960, 5-county study area and Kentucky

Age group	5-county study area	Kentucky
	Percent	Percent
5-6	37.6	44.9
7-13	93.7	95.8
14-15	85.5	88.5
16-17	63.4	70.1
18-19	22.9	35.5
20-24	3.8	11.8

Source: U.S. Census of Population (132, 1960, Kentucky Ser. C).

Agriculture in the Region

The dominance of agriculture in the 5-county area must be considered in any development program. The data in table 3 show the most important crops in this area, the acreage devoted to each, and the crop production. Acreage and production are also shown as a percentage of the totals for the State. Table 4 shows livestock and poultry products, and compares the numbers in the study area with the totals for Kentucky.

The 5-county study area is located in the Eastern Pennyroyal type-of-farming area. Agriculture is devoted predominantly to small-scale, diversified family farming. Tobacco is the major commercial crop, with considerable quantities of corn and hay raised, mainly as feed for the farm livestock and poultry. The sale of hogs, manufacturing milk, eggs, and poultry provides most of the other cash income.

Agriculture in this area has low capital/labor and capital/output ratios (17). Only 44 percent of the tobacco acreage was farmed by mechanized methods; only 10 percent of the corn acreage was farmed by fully mechanized methods. Corn production averaged only 42 bushels per acre because of inadequate application of fertilizer. Yields of milk from dairy cows were low because of the poor quality of stock. Yields of eggs were low because of inadequate investment in laying facilities, equipment, and feed (17).

Table 3.--Major crops harvested in the 5-county study area: Acreage harvested, yield, and quantity sold, and percentage of total for State, 1959

Crop	Unit	Acreage harvested	Total production	Yield per acre	Quantity sold	Percentage of Kentucky total			
						Acreage harvested	Total	Yield per acre	Quantity sold
		Acres	Thous.		Thous.	Pct.	Pct.	Pct.	Pct.
Tobacco (burley).....	Lb.	13,411	23,489	1,689	(1)	6.6	7.7	105.1	(1)
Corn[2].....	Bu.	97,546	4,047	41	811	6.2	5.8	93.2	4.1
Soybeans[3].....	Bu.	414	8	20	(1)	.2	.2	90.9	(1)
Hay:									
Lespedeza.....	Ton	46,972	58	1	2	8.6	8.3	96.9	4.7
Other[4].....	Ton	50,457	81	2	(1)	5.5	5.5	101.3	(1)
Other small grains[5]...	Bu.	12,155	261	21	(1)	3.7	3.0	80.8	(1)
Other seed crops.....	Bu.	8,228	--	--	--	--	--	--	--
All cropland harvested.....		229,183	--	--	--	--	--	--	--

[1] Not available.
[2] Harvested for grain only.
[3] Harvested for beans only.
[4] Includes alfalfa, clover, timothy, grass silage, and small grains cut for hay.
[5] Includes sorghum, wheat, oats, barley, and rye.

Source: U.S. Census of Agriculture (126 , table 11, 1959).

Table 4.--Livestock and livestock products in 5-county study area: Production, value, and percentage of total for State, 1959

Livestock and products	5-county study area			Percentage of Kentucky total		
	Total on farms	Sold		Number on farm	Sold alive	
		Total	Value		Number	Value
	Number	Number	Thous. dollars	Percent	Percent	Percent
Livestock:						
Milk cows	46,683	(1)	(1)	10.0	(1)	(1)
Heifers that have calved	17,487	(1)	(1)	3.6	(1)	(1)
Heifers and heifer calves	38,338	(1)	(1)	6.8	(1)	(1)
Steers and bulls	16,832	(1)	(1)	3.9	(1)	(1)
Cattle	119,340	21,300	3,516	6.1	4.6	4.4
Calves		38,500	2,455		7.3	6.0
Hogs and pigs	98,411	92,400	2,680	6.0	5.2	5.2
Chickens	[2] 372,150	[3] 123,900	(1)	6.8	7.2	(1)
Broilers	(1)	2,211,400	(1)	(1)	16.2	(1)
Livestock products:						
Milk[4] (lb.)	(1)	149,930,000	(1)	(1)	8.7	(1)
Cream[5] (lb.)	(1)	46,600	(1)	(1)	3.6	(1)
Eggs (doz.)	(1)	1,424,700	(1)	(1)	6.3	(1)

[1] Not available. [2] Chickens on the farm 4 months or older. [3] Chickens other than broilers. [4] Milk sold as whole milk. [5] Cream sold in pounds of butterfat.

Source: U.S. Census of Agriculture (126, tables 8-10, 1959).

Labor Force and Employment Characteristics

The proportion of population age 14 and over in the labor force in the Glasgow trade area is lower than in the United States. This difference is appreciable for females (26 percent in 5-county study area, compared with 34 percent in the United States). This lower labor force participation in the 5-county region implies "hidden" unemployment, i.e., more people would be in the labor force if jobs were available at competitive wage rates. The amount of hidden unemployment was estimated to be the same as that found to exist in Adair County, Ky., in a 1960 survey conducted by the State for that county (58). Adair County is adjacent to the counties in the Glasgow trade area and is similar in social structure. The Adair survey showed that about 30 percent of the people not now gainfully employed (i.e., housewives, retired persons, persons in school, unpaid family workers, etc.) considered themselves to be available for either full- or part-time employment.

The data in table 5 present the number of persons employed and the percent of total employment in each major industry group in the 5-county region. A percentage breakdown of employment for Kentucky and for the United States is also presented for comparison. The 5-county study area has a higher proportion of its work force in agriculture (almost half) than Kentucky as a whole. The study area has a much lower proportion in the manufacturing industries, with the exception of the apparel industry and the lumber and wood products industry. Since the Glasgow trade area is predominantly an agricultural region, it is perhaps surprising that the region has a lower proportion of its work force in the food processing industry than Kentucky as a whole. The region also has lower than average proportions of its work force in transportation, utilities, and business and professional services. This reflects the low level of industrialization of the area's economy.

The data in table 6 present the number of employed persons in each of the major occupational groups. Comparison of figures for Kentucky and for the United States emphasize the low percentage of professional, managerial, and skilled workers in the 5-county study area. A lack of workers in these categories is an important constraint in the operation of a regional development program. The characteristics of the 5-county area are the foundations upon which a development program must be built.

Table 5.--Number of persons employed in the 5-county study area, and percentage employed in each major industry group, 5-county study area, Kentucky, and the United States, 1960

Industry group	5-county study area		Kentucky	United States
	Number	Percent	Percent	Percent
Agriculture	9,989	41.7	14.1	6.6
Forestry and fisheries	5	(1)	.1	.1
Mining	358	1.5	4.0	1.0
Construction	1,429	6.0	6.3	5.9
Manufacturing	2,681	11.2	21.2	27.1
Furniture, lumber, and wood	438	1.8	1.9	1.7
Primary metals	15	.1	1.0	1.9
Fabricated metals	12	(1)	1.4	2.0
Machinery, excl. electrical	24	.1	1.6	2.4
Electrical machinery and equipment	24	.1	2.5	2.3
Motor vehicles and equipment	4	(1)	.7	1.3
Other transportation equipment	4	(1)	.3	1.5
Other durable goods	56	.2	1.2	2.1
Food and kindred products	425	1.8	3.2	2.8
Textile mill products	4	(1)	.3	1.5
Apparel, etc	1,448	6.1	2.2	1.8
Printing and publishing	135	.6	1.4	1.8
Chemicals and allied products	24	.1	1.4	1.3
Other nondurable goods	68	.3	2.1	2.7
Railroad and railway express	61	.3	2.1	1.5
Trucking service and warehouses	207	.9	1.5	1.4
Other transportation	96	.4	1.0	1.4
Communications	131	.5	1.1	1.3
Utilities and sanitary	213	.9	1.5	1.4
Wholesale trade	585	2.4	2.6	3.4
Food and dairy product stores	644	2.7	2.8	2.6
Eating and drinking places	477	2.0	2.5	2.8
Other retail trade	1,985	8.3	9.4	9.4
Finance, insurance, and real estate	310	1.3	3.0	4.2
Business services	28	.1	.6	1.2
Repair services	380	1.6	1.5	1.3
Private households	820	3.4	3.1	3.0
Other personal services	655	2.7	2.8	3.0
Entertainment and recreation	123	.5	.7	.8
Hospitals	353	1.5	2.3	2.6
Educational services:				
Government	879	3.7	4.0	3.9
Private	72	.3	1.2	1.3
Welfare, religious, nonprofit	182	.8	1.3	1.3
Other professional	282	1.2	1.9	2.5
Public administration	629	2.6	3.9	5.0
Not reported	352	1.5	3.5	4.0
Total	23,926	100.0	100.0	100.0

[1] Less than 0.05 percent.

Source: U.S. Census of Population (132, 1960, Kentucky, ser. C, table 85, and U.S. Summary, ser. C, table 91).

Table 6.--Distribution of the male and female employed labor force, by occupational grouping, 5-county study area, Kentucky, and the United States, 1960

Occupation	Male				Female			
	5-county study area		Kentucky	United States	5-county study area		Kentucky	United States
	Number	Percent	Percent	Percent	Number	Percent	Percent	Percent
Managers and professional.....	1,948	10.9	15.9	20.9	934	15.2	17.1	16.7
Clerical.....	365	2.1	5.4	6.9	900	14.7	24.1	29.7
Craftsmen and foremen.....	1,818	10.2	17.3	19.5	71	1.2	1.0	1.2
Operatives.....	1,853	10.4	21.2	19.9	1,389	22.7	16.5	15.4
Other[1].....	11,822	66.4	40.2	32.8	2,826	46.2	41.3	37.0
Total.....	17,806	100.0	100.0	100.0	6,120	100.0	100.0	100.0

[1] Includes farmers, farm managers, sales, service workers, and laborers.

Source: U.S. Census of Population (132, 1960, Kentucky, ser. C, table 84, and U.S. Summary, ser. C, table 87).

III. GENERAL FORMULATION OF THE MODEL FOR A REGIONAL DEVELOPMENT PROGRAM

The methodology for formulating an activity analysis model is presented below. First, the goals and time span of the development program as expressed in the model are discussed; second, the formal model selected for the analysis, is described, including a comparison of the selected model with similar models used in development planning; and finally, the operation of the model is described.

Goals and Time Span of the Development Program

The essential goal of planning for economic development is to increase per capita income. In the context of planning for depressed regions of the United States, the goal may be expressed in terms of decreasing the per capita income gap between the residents of the region to be planned for and the average for the Nation over some specified time period.

Like Sandee (A6), Chenery and Kretschmer (A2), and Manne (A5), a time span of 10 years was selected for the development analysis. A 5-year period does not take care of lags between investments and outputs; a 20-year period appears to be too long in view of the uncertainty regarding technology and overall economic conditions.

As in the models developed by Manne (A5) and Chenery and Kretschmer (A2), the model is stated in terms of planning increases in production above existing capacity levels to meet targets of increased income and consumption. It is generally assumed that the existing economy is in a state of equilibrium at full utilization of capital. The model considers changes in the existing economy in two respects: (1) Available additions to the labor force of persons currently not considered to be in the labor force, but who would accept jobs at competitive wage rates if such jobs existed, i.e., "hidden" unemployment; and (2) technological change in existing agricultural activities. This process of technological change often involves substituting capital for labor in existing agriculture. The first mentioned change is outside the formal framework of activity analysis; but, the second has been introduced in the model framework by the use of "conversion" activities and is unique in the model applied in this study.

As for the time path of development, Manne's method was followed, wherein the economy must achieve the consumption goal in the 10th year, and balance the flows of commodities, capital, and labor. To avoid the "edge effects" of a finite time span, however, we assume, as does Frisch (A4), that development must be continuous during the decade, and self-sustained growth occurs beyond the terminal year. The extent to which the goal of self-sustained growth is in fact achieved

by the end of the planning period is shown in the model by the foreign balances on current account.

Since we are concerned with the situation in the terminal year, it is necessary to determine what proportion of the capital stock required by the various activities should be invested in this year. We assumed, as did Manne, that this proportion is 15 percent of the 10-year investment. Our reasoning is as follows: If capital stock grows at a constant absolute amount every year, then 10 percent would be invested in the final year. But if capital stock grows at a constant proportional rate, the proportion invested in the final year would be more than 10 percent. Obviously, this proportion would depend on the overall rate of growth of output and capacity, but it can be shown that for annual rates of growth ranging from 5 to 10 percent, the proportion of total capacity to be invested in the final year would be close to 15 percent (A5). Also, 15 percent approximates the average rate of return on capital in the United States, and rate of return on capital is an item of cost in the model.

The actual demand for capital in the final year exceeds 15 percent of the total by the estimated depreciation or replacement rate. For the sake of simplicity, capital is considered as being either equipment, with a 10-year life, or plant, with a 20-year life. Since imported capital is exclusively equipment, and local capital formation is almost exclusively construction, 10 percent is added to the annual requirement for imported capital, bringing the total to 25 percent, while 5 percent is added to the annual requirement for local capital formation.

Description of the Formal Model

A linear programming model is used here for the application of activity analysis (A1).[2] This linear programming model consists of a technological matrix which may be defined as a collection of vectors (activities). Each activity is comprised of a list of commodities, various quantities of which are required as inputs in order to produce a unit of specified outputs.[3] When the vectors are put together, they form a matrix of all the conceivable commodity flows in the program.

Flexibility is provided in the model by including alternative economic activities that may be selected in the solution to satisfy the basic requirements (constraints). The model provides a procedure which searches for an optimum solution such as cost minimization or income maximization. In the

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[2] Section IV contains a detailed discussion of this basic model. The computer routine used is an M3 linear and separable programming system developed at Standard Oil of California, and routined for solution on the IBM 7090. The same routine was used by Manne (A5).

[3] A commodity in the sense used here refers to all economic flows--goods, services, labor, and capital.

procedure, those activities and the levels at which the activities are to operate are selected to achieve the optimum solution.

Our model uses the highly disaggregated form of the technological matrix, found only in Manne's partial equilibrium model, in an application to the analysis of a whole economy. Unlike any of the applied models for economic development, except the one used by Chenery and Kretschmer (A2), the model used in this study has an endogenous determination of the level of individual exports.

Another feature of the technological matrix in this model is the inclusion of alternative technologies, alternative scales, and joint products. Alternative scales are permitted by having "small" and "large" scale activities; the large-scale activity is frozen out of the solution in those cases where a preliminary solution indicates that the market is inadequate to justify its inclusion. Joint products create no problem in the model because each of the outputs can be exported at the market price.

The labor requirements are detailed to a far greater extent than in any other applied model. Unlike the Chenery-Kretschmer (A2) and Manne (A5) models, labor is viewed as a major limiting resource, and careful consideration is given to the consistent projection of the labor force constraints. These constraints are discussed in more detail later. The inclusion of activities to import and export labor of different kinds and in different seasons makes it possible to calculate labor shortages and supluses at competitive wage rates. This provides an important internal check on the feasibility of development planning for the region.

A major feature of the technological matrix is the large number of activities that delineate the complex interrelations of agriculture and manufacturing. This is essential for planning industrialization of a rural region. The activities included in the matrix permit testing various vertical combinations of manufacturing and agriculture, often termed "agri-business"; e.g., soybean production and processing, hog production and slaughtering, truck crop farming and freezing, dairying and manufactured milk processing, and the like. The various vertical combinations are not forced in the model solution, since all commodities used can be either locally produced, imported, or exported.

The agricultural activities also are related to, and influenced by, the needs of the manufacturing sectors through the operation of the "conversion activities". Thus, agricultural labor is freed for use in industry by introducing aspects of technological change in the existing agricultural sectors.

Functioning of the Model

In the model, targets for population, income, and local consumption for the 10th year of the development program are given. The size and composition of the local labor force available and the constraints on natural resource use and on

export demand are also given. The model predicts the following: (1) The income generated in the area by the development program; (2) the activities to be included; (3) the net "foreign balance" both on current and capital account; (4) the fixed investment required by industry and government; and (5) the labor surplus and deficit, by type.

Figure 1 shows (a) which aspects of the development program are given and which are solved by the computer routine, and (b) the interacting real flows of commodities, capital, and labor that would be taking place in the 10th year.

The level of production in each of the manufacturing, agricultural, and local service activities included in the model is determined by the operation of the model in response to local consumption demand, local interindustry demand, and export demand. The model also allows for alternatives in imported commodities should domestic production be too expensive.

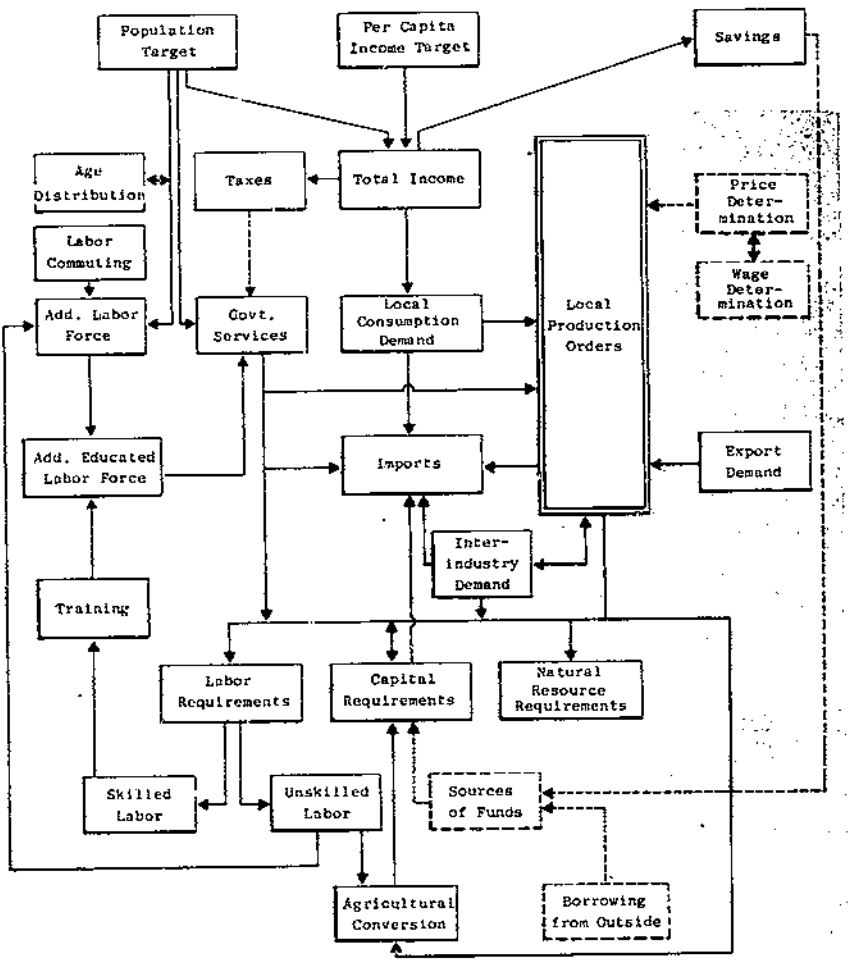
The demand for a good or service that results in a local production order sets in motion a series of subsequent demands for one or more of the following: (1) Imported commodities and services representing charges against foreign exchange on current account; (2) commodities and services produced by other industries in the model (interindustry demand); (3) local natural resources (stumpage, tobacco allotment, new land); (4) fixed domestically produced capital; (5) fixed imported capital representing charges against foreign exchange on capital accounts, and (6) labor, both locally available and imported.

The result of a demand created for a unit of fixed capital or labor can be followed in the flow diagram. Some capital requirements are translated directly into import demand. Most machinery and equipment requirements fall in this category. Some capital requirements, especially for construction of buildings, are translated back to a local industry production order. The model, however, represents only the 10th year of the development program, and the capital requirements are those of that year, not of the entire 10 years.

Labor for the required output is separated into four categories: (1) Managerial (including professional and supervisory); (2) clerical (including teaching); (3) skilled; and (4) unskilled (including semiskilled). Unskilled labor is further divided into six parts because of its seasonality (each part accounting for a 2-month period).

Projections of population, age distribution, school enrollment, and existing "hidden" unemployment provide the basis for determining the labor force available from local sources. In addition, the model provides for labor to commute from neighboring areas (as well as to neighboring areas) at competitive wages and salaries. A source of local unskilled labor, in addition to new entrants to the labor force, is the pool created by technological change where capital is substituted for labor. It is assumed that there is no pool of already

DEVELOPMENT PROGRAM FLOW CHART FOR THE
ACTIVITY ANALYSIS MODEL



NOTE: The unshaded area contains items that are given; the shaded area contains items that are predicted by the model.

Figure 1

trained skilled workers; skilled labor from local sources is provided in the model via a labor training activity.

Prices in the model are shadow prices; that is, they reflect the value of scarce resources as determined by the constraints. Each commodity on which there is an effective constrant carries a positive price. A commodity on which there is no effective constraint has a price of zero.

A shadow price for a produced commodity is the sum of the shadow prices for the imputs. The export capacity of a commodity has a shadow price if exportation of that commodity is constrained by the export constraint. This shadow price may be interpreted as export profit.

The wages received by labor (shadow prices of labor in the model) are determined by the value of the constraints, as for other commodities. If labor could not be imported or exported, the price of labor would reflect the value of the labor to the marginal user. Any unemployment (implying no effective constraint on use) would result in a zero wage. Since labor may be imported and exported (labor commuting), the wages must be within the range set by the import and export prices.

IV. MATHEMATICAL FORMULATION OF THE REGIONAL DEVELOPMENT PROGRAM MODEL

Notation

It is first necessary to introduce some notation that will be used in the mathematical presentation:

X_j = 10-year increase in the rate of yearly production of activity j, where $j = 1 \ldots N_p$ (including industry, agriculture, and services, and excluding foreign trade).

X^E_{iu} = 10-year increase in the rate of export of commodity i, where $i = 1 \ldots V_1$; $u = 1, 2$.

X^M_i = 10-year increase in the rate of import of commodity i.

X^c_j = 10-year increase in rate of utilization of conversion activity j.

a_{ij} = Input (-) or output (+) of commodity i on current account per unit of activity j, where $i = 1 \ldots V_1$ and $j = 1 \ldots N_p$.

c_{ij} = Conversion coefficient for conversion activity j, input (-) or output (+) of the ith commodity due to the jth conversion activity, where $j = N_p + 1 \ldots N_c$.

b_{ij} = Fixed, domestically producible capital goods of type k required per unit of annual capacity of activity j, where $i = V_l + 1 \ldots V_k$.

k_j = Amount of foreign exchange required on capital account per unit of annual capacity of activity j (negative number in the matrix).

q_j = Amount of foreign exchange required on current account per unit of annual capacity of activity j (negative number in the matrix).

l_{ij} = Amount of labor of type i used (-) or freed (+) per unit of activity j, $i = V_c + 1 \ldots V_l$.

l^{c}_{ij} = Amount of labor of type i used (-) or freed (+) per unit of conversion activity j.

C_i = 10-year increase in the rate of consumption of commodity i (domestically producible).

C_f = Total 10-year increase in the rate of import of non-domestically producible consumption goods.

P^{E}_{iu} = Export price of commodity i; u = 1, 2.

P^{M}_{i} = Import price of commodity i.

$\overline{E}_{iu}$ = Limitation on the export of commodity i; u = 1, 2.

$\overline{L}_i$ = Limitation on availability of labor of type i, where $i = V_c + 1 \ldots V_l$.

r_i = Fraction of capital of type i assumed to be invested in the terminal year, where $i = V_l + 1 \ldots V_k$.

r = Fraction of foreign exchange on capital account invested in the terminal year.

Z_1 = Total foreign exchange cost on current account.

Z_2 = Total foreign exchange cost on capital account.

In order to facilitate the reading of this report, the following may be noted:

A. Activities are designated in the model as follows:

(1) $j = 1 \ldots N_p$ for all production activities.

(2) $j = N_p + 1 \ldots N_c$ for all conversion activities.

The N_c activities are involved in the interrelated commodity flow. In addition to these N_c activities, we have export and import activities. In general, we should designate the export and import activities in addition to $j = 1 \ldots N_c$, but, since there is a unique correspondence between the list of commodities in our model and the list of export and import activities, we designate export and import activities with a superscript E or M but use as a running index the list of commodities $i = 1 \ldots V_k$.

B. Commodities are designated in the model as follows:

(1) $i = 1 \ldots V_1$ for producible domestic commodities (except domestic capital goods).

(2) $i = V_1 + 1 \ldots V_c$ for the "dummy" commodities controlling conversion from the old sector.

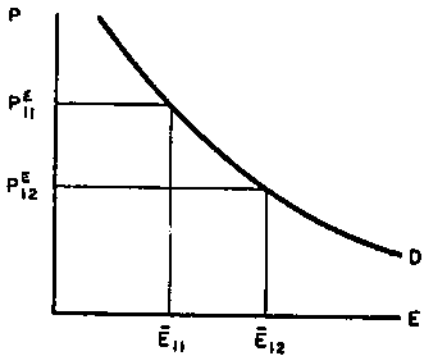
(3) $i = V_c + 1 \ldots V_l$ for various types of labor.

(4) $i = V_l + 1 \ldots V_k$ for domestically produced capital goods.

We note that X^E_{i2} refers to export activity to far regions (Area 2), where $i = 1 \ldots V_k$. We note also that $X^E_{iu} = X^M_i \equiv 0$ for $i = V_1 + 1 \ldots V_c$, $u = 1,2$, since the conversion commodities are dummy commodities that are neither exportable nor importable.

Treatment of Exports

In a linear model, a paradox can arise with regard to exports: If an export activity is "profitable" but unconstrained it will be operated at an unlimited rate. One could introduce "decreasing returns" in production into the model to limit exports in such a case, but it was felt that market restrictions and increased transportation and sales costs would lead to decreased net realized prices and thus serve the same purpose. A downward sloping demand curve was approximated by a step function with the following interpretation: Our region can export commodity i for a price P^E_{i1} up to the level $\overline{E}_{i1}$. Further expansion of exports can be made for the price P^E_{i2}, with the maximum rate of export of this additional activity of $(\overline{E}_{i2} - \overline{E}_{i1})$. Hence, we have for each exportable commodity two export activities (except for a few special cases), each having an upper bound.



Treatment of Technological Change

As pointed out earlier, technological change in this study is viewed as the adoption of up-to-date technology leading to a conversion of part of the economy. It is true that within a 10-year period new technologies will arise, but available alternatives in the existing technology provide ample room for improvement at the present stage of a backward region's development. Further technological changes can be introduced by revising the technological coefficients in the matrix.

Since the amount of manufacturing currently existing in the Glasgow trade area in Kentucky is insignificant, the possibilities of technological change may be confined to agriculture. The basic tool for introducing such changes is the "conversion activity." In every agricultural process about which data were available and applicable to the Glasgow study area, conversion activities whose level of operation is denoted X_j^c were introduced. Conversion activities consist of the introduction of mechanization into agriculture with a consequent release of labor without a change in output, or the introduction of mechanization and other inputs with a consequent release of labor and increase in output. Conversion activities are introduced in addition to the usual expansion programs of agriculture.

Appendix A contains a more detailed discussion of conversion activities. But the general nature of these activities is described here so as to incorporate these activities in the balance equations that follow.

The Balance Equations

Commodities

Let us consider first the commodities that are producible in the region. Now $\sum_{j=1}^{N_p} a_{ij} X_j$ is the 10-year increase in total domestic production of commodity i net of current industrial demand for these commodities. $\sum_{j=N_p+1}^{N_c} c_{ij} X_j^c$ is the total increased (or required) output of commodity i as a result of the conversion process; $X_{i1}^E + X_{i2}^E$ is the total increase in the export of commodity i; X_i^M is the total increase in the import of commodity i; and C_i is the total increase in the

consumption of commodity i. Since among our "producing" activities we have introduced services and trade and have treated them symmetrically for all commodities, there is no need for explicit statements of these demands. Our first set of balance equations, therefore, becomes:

$$\sum_{j=1}^{N_p} a_{ij} X_j + \sum_{j=N_p+1}^{N_c} c_{ij} X^c_j + X^M_i - (X^E_{i1} + X^E_{i2}) \geq C_i \; ; \; i = 1 \ldots V_1 . \quad (1)$$

This essentially states that net increase in output from production plus net increase as a result of conversion plus increase in imports minus increase in exports should be at least as great as the increase in consumption. For all purely intermediate goods (non-consumables), $C_i = 0$.

Exports

In addition to the constraints in equation (1), there are constraints imposed on exports representing limitation of export demand. In order to put separate constraints on exports, it is necessary to have equations expressing export demands for each exportable commodity. These balance equations are:

$$\left.\begin{aligned} X^E_{i1} - \bar{E}_{i1} &\leq 0 \quad (2) \\ X^E_{i2} - (\bar{E}_{i2} - \bar{E}_{i1}) &\leq 0 \quad (3) \end{aligned}\right\} \; ; \; i = 1 \ldots V_k .$$

Conversions

Each conversion activity is restricted by the existing size of the sector. For example, if we are contemplating the conversion of the corn sector of agriculture, then total converted acreage cannot exceed existing acreage. Since there are several possible means of conversion (highly mechanizing, mechanizing and improving with fertilizer, etc.), we introduce for each sector a dummy commodity called, for example in the case of corn, "corn conversion." These conversion commodities are enumerated $i = V_1 = 1 \ldots V_c$.

Let S_{ij} be defined:

$$S_{ij} = \begin{cases} 1 \text{ if } X^c_j \text{ is a conversion activity of commodity i.} \\ 0 \text{ if } X^c_j \text{ is not a conversion activity of commodity i.} \end{cases}$$

Let λ_i be the upper limit to the conversion of commodity i. Then we have a set of constraints of the form:

$$\sum_{j=N_p+1}^{N_c} S_{ij} X^c_j - \lambda_i \leq 0 \; ; \; i = V_l + 1, \ldots V_c . \qquad (4)$$

Labor

There are 11 labor equations, 1 for each of the 4 labor categories (managerial, clerical, skilled, and unskilled), one for each of the 2-month seasons applying to unskilled labor, and one expressing the transfer of educated persons from the unskilled category to the skilled category by operation of the labor training activity. The use of local labor in each category is constrained by the amount of local labor available. The model provides for labor to commute into and out of the area by including activities to import and export labor at given wage levels. As in the commodity equations, the use of labor in production or export[4] is negative, and the availability of labor through conversion or import is positive. Thus, the set of balance equations is as follows:

$$\sum_{j=1}^{N_p} l_{ij} X_j + \sum_{j=N_p+1}^{N_c} l^c_{ij} X^c_j + X^M_i - X^E_{il} + \bar{L}_i \geq 0 \; ; \; i = V_c + 1 \ldots V_l \qquad (5)$$

Domestic Capital Goods

The structure of domestically producible goods is very simple, consisting primarily of the construction industry and livestock capital. We are interested here only with the fraction

[4] Export represents surplus at the prevailing wage, and may be considered as equivalent to unemployment.

of domestic capital that will be required for the 10th year; let r_i be this fraction. The set of balance equations for domestically producible capital goods is, therefore:

$$\sum_{j=1}^{N_p} r_i b_{ij} X_j + \sum_{j=N_p+1}^{N_c} r_i b_{ij} X^c_j + X^M_i - (X^E_{i1} + X^E_{i2}) \geq 0 \; ; \; i = V_l + 1 \ldots V_k \quad (6)$$

Since most of the domestic capital goods required in our region are of the nature of construction, they are not exportable, importable, or consumed.

Foreign Exchange

The economy of the 5-county study area is small and agrarian in nature. Industrial raw materials, fuels, and most other types of intermediate goods, business services, and fixed capital must be imported. In addition, a significant portion of consumer goods, also not producible in the study area, is imported (C_f). "Foreign exchange" is earned by exporting goods produced locally and is used to finance imports into the region of required goods not locally produced. Financing from outside the region covers the remaining deficits on current account and on fixed capital account. If we let Z_1 be the funds required from outside for current account, and Z_2 be the funds required from outside for fixed investments, then we have the following two balance equations:[5]

$$\sum_{j=1}^{N_p} q_j X_j + \sum_{j=N_p+1}^{N_c} q^c_j X^c_j + \sum_{i=1}^{V_k} P^E_{i1} X^E_{i1} + \sum_{i=1}^{V_k} P^E_{i2} X^E_{i2} - \sum_{i=1}^{V_k} P^M_i X^M_i + Z_1 \geq C_F . \quad (7)$$

$$\sum_{j=1}^{N_p} rk_j X_j + \sum_{j=N_p+1}^{N_c} rk^c_j X^c_j + Z_2 \geq 0 . \quad (8)$$

[5] By definition, all q's and k's are cost items and are negative numbers. P's are prices and are positive numbers.

So far, there has been no discussion of savings. In this type of a regional model, the easiest way of treating savings is as a substitute for Z_1 or Z_2. In other words, we have specified a certain target for the consumption sector ($C_1 \ldots C_n$, C_f) of locally producible or importable commodities. If the income created by the program exceeds consumption, then the positive difference is savings or income taxes available to cover a certain fraction of the capital or government service requirements. This is so since savings are a perfect substitute for foreign exchange. For this reason, there is no need to introduce savings explicitly as a constraint.

The Objective Function

The complete structure of the activity analysis model has been developed. The remaining question now is what is the objective function? The belief that the scarcest resource in a depressed area is capital, our objective is then to minimize the total foreign funds required for the program. In other words, the activities and activity levels were selected to minimize the total imported funds required for the program, i.e., minimize the sum of Z_1 and Z_2.[6] On the surface, it may appear that the criterion for the selection of industrial activities should have been profitability, i.e., rate of return on capital. In fact, by introducing major elements of competition between our region and the outside world, the model reaches a solution that is not significantly different from that which would have been reached if profitability had been the criterion. The products of the industries chosen must compete with imports; they must sell in export markets at prices that represent competitive market prices. In addition, the most important local resource is labor, and the price of labor is forced into a competitive range by the prices assigned to the import and export activities for labor.

[6] The same objective was used by Manne (A5). Also, as mentioned above, the cost calculations in the objective function are for the last year of the program, and thus, include only a portion of the fixed capital (Z_2). This portion is made up of two parts: (1) Estimated investment required in the 10th year, or anticipated rate of return on capital, taken as 15 percent; and (2) depreciation, taken as 10 percent on imported capital (mainly equipment); 5 percent on factory buildings; and zero on farm buildings, office buildings, and school buildings. Road and residence building construction was estimated directly in terms of annual requirements.

V APPLICATION OF THE MODEL TO THE GLASGOW TRADE AREA

The worth of the mathematical model described in Section IV is measured by the ability to apply it to the development planning of a region. A principal task of this research effort, therefore, has been to determine whether adequate data can be gathered to permit realistic quantification of the parameters and constraints in the equations. The test was made for the Glasgow trade area. Results of this test show that such a model can be used as a tool for regional development planning in the United States.[7]

The construction of the applied model is described in this section. The description is divided into two parts: (1) The construction of the activity vectors (together with an explanation of the sources of data); and (2) the construction of the targets (population, income, etc.) and constraints (labor force availability and export demand).

Construction of the Activity Vectors

The model as applied to the Glasgow trade area has 586 columns representing activities and 239 rows representing balance equations. Of the 586 columns, 339 represent real activities, and 247 are "slack variables."[8] Of the 239 rows, 115 represent equations showing flows of commodities, and 124 represent "dummy" equations for exports.

The real activities are as follows:

62	manufacturing production activities
32	agricultural production activities
13	agricultural conversion activities
15	other production activities (including local services, construction, government, livestock capital production, and labor training)
129	export activities
88	import activities

[7] Background data and information used in this study and as a basis for this report are in the files of the Area Economic Development Branch, Economic Research Service, U.S. Department of Agriculture, and the Economic Development Division, Stanford Research Institute. The available background information include the following major items: Basic tables for projecting population, labor force, income, and consumption; detailed description of selected activities; export and import prices; worksheets for constructing the activity vectors; and computer runs.

[8] Slack variables are artificial variables required in the simplex solution to the linear programming problem to convert inequalities to equalities.

It is theoretically possible to have many more activities, but the desire to complete the construction of the matrix in a reasonable period of time made it necessary to limit the number. Besides, many manufacturing and agricultural activities are not likely to be suitable for the region. Therefore, it was not desirable to construct activity vectors for them. Examples of such activities are heavy capital goods industries, chemical industries requiring large water supplies, and advanced engineering industries requiring large numbers of highly trained engineers and technicians.

Precise research tools were not available to aid in selecting manufacturing and agricultural activities suitable for the area. However, we believe that we have selected a reasonable set of industries on the basis of a general knowledge of the economy of the area and through studies on economic opportunities and resources in the area. It is possible that some suitable industries have been missed, in which case, export earning potential has been understated.

The 62 production activities in manufacturing represent 37 different industries; the others represent variations in product mix or in scale of operation. There were 10 cases in which scale economies could be quantified and which seemed sufficiently important to warrant construction of vectors for two scales of operation.[9]

Of the 37 manufacturing activities, 7 are for food processing, 8 for lumber and wood products, 4 for apparel, and 5 for cement and concrete products. The remaining ones are widely scattered among the 20 two-digit Standard Industrial Classification codes. In fact, 15 of the 20 two-digit SIC manufacturing industries are represented in the applied model.

Of the 32 agricultural production activities, 18 represent separate agricultural processes and 14 variations in scale or level of efficiency. Five of the 13 agricultural conversion activities represent alternative ways of converting corn.

A wide variety of sources was used to construct the production vectors. Appendix A presents a brief description of each activity vector, and the sources used to construct it.

About 115 commodities (representing goods and services, capital, and labor) were used in the matrix as the inputs and outputs of the production activities. When an input required by one activity appeared to be similar to an output of another activity within the region, this output was assumed to satisfy the input requirement. For example, paper containers might be required for packaging frozen snap beans. If some other regional activity was producing paper containers that appeared to be suitable for such a use, it was assumed that they satisfied the requirement by the frozen snap bean activity

[9] In the operation of the model both scales are included in the matrix on the first run; the efficient scale will always be chosen for the solution. Then, if the level of operation of that activity is too small to justify use of the efficient scale, that activity will be "frozen out" on the second run.

for paper container. However, a certain amount of judgment went into this decision, and, in some cases, the output and input might not be a perfect match. Where there appeared to be no commodity produced within the region to satisfy a specific input requirement, the commodity was considered to be an import.

In the case of labor, a decision had to be made as to whether the labor required was skilled or unskilled. In most industries, occupations earning $2.00 an hour or more were classified as skilled. However, in some highly unionized industries, such as slaughtering where the basic wage is $1.88 an hour, only occupations earning $3.00 an hour or more were classified as skilled.

Where the buildings needed for a production activity were not simple factory shells, it was necessary to combine factory construction with other kinds of construction, so that the construction cost would approximate the actual situation. Thus, in the model, cattle are slaughtered and fluid milk is produced in "office buildings," because the labor and materials used in constructing office buildings comes closest to the labor and materials required for a slaughterhouse or a fluid milk plant. In other words, it was not feasible to create a new construction activity for each type of plant needed.

The import and export vectors were created by determining the wholesale price of a unit of the commodity to be traded and then adding transport costs for imports and deducting transport costs and other distribution costs for exports.

An export demand function is approximated in the model by two points on a demand curve. (See Treatment of Exports in Section IV.) The point representing the smaller amount of sales at the higher realized price may be considered to be for exports to a regional market that is contiguous with the Glasgow trade area (perhaps central and western Kentucky and Tennessee), called area 1. A second point on the curve, representing larger sales at a lower realized price, may be considered to be for exports to a broader, national market, called area 2. The realized export price for shipments to area 2 would be lower than that for shipments to area 1 because shipping distances, other distribution costs (e.g., maintaining a national sales agency), and the potential competition from other producers located nearer the more distant markets are all greater. Deductions from gross export prices for distribution costs other than for transportation are considered to be 5 percent of the gross price for shipments to area 1, and 8 percent of the gross price for shipments to area 2. These percentages are varied somewhat for products known to bear particularly heavy or light distribution cost burdens.

Transportation costs are for the most part trucking costs on less than load shipments of over 2,000 pounds, taken as the class rate on shipments from Glasgow to Bowling Green, Ky., for area 1 exports, and to Chicago for area 2 exports.

Railroad rates were used for a few bulky commodities known to be shipped largely by rail.

Figure 2 gives an idea of the matrix and shows the activity columns and commodity rows. The activity vectors that apply to the production of three commodities, wooden handles (C060), brooms (C061), and factories (K003) are quantified in the figure.[10] Wooden handles are produced by activity I015. One unit of intensity of activity I015 produces 14 million handle units (a handle unit is a handle containing one-seventh of a board-foot of lumber). This activity uses various amounts of finished lumber of less than No. 1 common, hand tools, corrugated fiber boxes, local services, labor, factory buildings, and imported goods, services, and fixed capital. Wooden handles are not required for final consumption within the Glasgow trade area, thus the zero in the right-hand side of the matrix (R013). However, they are used in the production of brooms (I016), and they may be exported (XI029 and XI030) to the constraints shown on the right-hand side. If brooms (C061) or some other product using wooden handles are to be produced in the region, and the domestic cost of production for activity I015 is too high, then the wooden handles may be imported by activity MI017 at a price of 1.26 units of foreign exchange per one activity unit of handles (i.e., at $0.09 per handle).

The production of wooden handles requires a certain amount of factory construction, 20 percent of which is taken as investment in the 10th year. The vector to produce factories is 0003.

The coefficients of production or use of each commodity in an activity are expressed in terms of the number of units of that commodity produced (+) or used (-) in operating the activity at one unit of intensity. A unit of intensity of a producing activity usually represents a small- or medium-sized plant of reasonable efficiency. The optimum solution determines the number of units of intensity at which each activity is to operate. Thus, if activity I015, production of wooden handles, is shown to operate at an intensity of 5.9, it means that the output of wooden handles is to be 5.9 times that of the size plant used in the model. This increased output may be handled by a much larger plant than the one used in the model or by several small plants. Since the form of the model is linear, all inputs to the activity are also 5.9 times that for one unit (thus, the need for considering alternative plant scales in the form of alternative activity vectors).

Sources of Data for Activity Vector Construction

The complete matrix has approximately 3,000 entries from 176 separate sources. These sources are listed at the end of this report, and the activities are described in Appendix A.

[10] The list of commodities and the identification of their associated activities of production and trade are presented in Appendix B.

The data used for constructing the agricultural activity vectors,including exports and imports, are believed to be highly reliable. Farm management manuals and other literature, especially of the Universities of Kentucky, North Carolina, Tennessee, and California, were used to construct these vectors. In addition, data for tobacco, corn, and livestocks for the 5-county study area were secured from a sample survey (17). Since agricultural commodities are relatively standardized and the prices for most of these are published by the U.S. Department of Agriculture, the estimates of import prices and export earnings are considered to be quite reliable.

Departments of Agricultural Economics in the various universities were excellent sources of data on food processing activities. Data on inputs to about 20 manufacturing industries included in the model were obtained from the industry profiles of AID (formerly ICA). These profiles were constructed for use in underdeveloped countries (159, 160, and 161). The main advantage of using AID data is that it provides consistent sets of inputs for a large number of industries and is complete in that it details commodity, labor, and capital requirements. Its disadvantages are that it provides input data for only one scale of activity for each industry, and that the research content of the profiles appears to be quite superficial. The results of our model would be more reliable if better data were available for the manufacturing activities.

Satisfactory published prices were available for standardized manufacturing commodities (except for frozen foods), but for nonstandardized products, the prices relate to the costs of production. The inclusion in the solution of an activity of this latter type (particularly furniture and some apparel industries) is less indicative of true feasibility than the inclusion of an activity producing a standardized product.

Targets and Constraints

The income target selected for the development program in the Glasgow trade area implies certain consumption goals, and the population target implies particular labor force availabilities. These targets, together with the constraints on important natural resources that are available for use in the area in any 1 year and the export demand constraints on potentially exportable commodities, make up the right-hand side of the matrix.

Income and Population Targets

The principal goal of the regional development program is to increase real per capita income by 69 percent, i.e., from about $1,000 in 1960 to about $1,740 in 1970. This is a 5.6 percent growth per annum during the decade. The income goal is designed to increase relative per capita income from 46 to 70 percent of the 1970 per capita income in the United

	I001...	I015	I016	....I053 A001...A019 C001.	C003	..0013 CA001..CA013 XI001..	XI029	XI030
T001								
.								
.								
T007								
C001								
.								
.								
.								
.								
C045		-0.3754	-0.0140		-0.0930			
C046		-0.2778						
.								
C054		-2.0000						
.								
C060		+1.0000	-0.0214				-1.0000	-1.0000
C061			+1.0000					
.								
.								
C079		-0.2400	-0.0300		-0.0150			
.								
C086								
L001		-5.0000	-1.0000		-4.0000			
L002		-4.0000	-1.0000		-2.5000			
L003		-8.0000	-3.0000		-23.5000			
L004		-56.0000	-5.0000		-20.5000			
L005		-9.3333	-0.8333		-2.7060			
L006		-9.3333	-0.8333		-3.0750			
L007		-9.3333	-0.8333		-3.6695			
L008		-9.3333	-0.8333		-3.9770			
L009		-9.3333	-0.8333		-3.7925			
L010		-9.3333	-0.8333		-3.2800			
L011								
XI01								
.								
XI03		-0.0070	-0.0053		-1.0000			
.								
.								
XI13								
FI01		-0.0825	-0.0460		-0.4436		+1.1370	+1.0800
FI02		-0.0191	-0.0015		-0.0288			
EI01								
.								
.								
EI29							+1.0000	
EI30								+1.0000
.								
.								
.								
E124								

NOTE: Some inputs to activity 0003 are omitted to simplify presentation.

Figure 2.--Technological M

) XA001...XA024 MI001...	MI017	....MI057 MA001..MA014 XL002, XL005...XL010 ML001...ML003, ML005...ML010	R013
	+1.0000		0.0000
	-1.2600		
			1.0000
			3.0000

States. In 1959 dollars, $2,485 is the projected U.S. per capita income; 70 percent of which is $1,740.[11] Seventy percent of the U.S. level was chosen for the 5-county goal because this is Kentucky's current relative position and has been its position for the past decade.

Tentatively, four alternative population targets were tested, with a development program designed for each. These targets were based on a projected natural rate of increase equal to average fertility rates in Kentucky and average survival rates in the U.S. and on manipulations of the net migration rate. They are as follows: (1) Population to decrease by 4,255 persons in the decade (based on rates of out-migration equal to those for each age-sex group experienced by the area in the 1950's); (2) population to be the same in 1970 as in 1960; (3) population to increase by 5,780, half the increase of population target No. 4; and (4) population to increase by 11,560, based on a net out-migration of zero in each age group.

Total income associated with each population target is the change in per capita income from 1960 to 1970 times the 1960 population plus the 1970 per capita income times the change in population.[12]

Labor Force Constraints

To find the number of local workers that would be available to implement a development program, projections were made of the net additions to the labor force that would be consistent with each population target. In order to make these projections, three major items had to be taken into account, in addition to the change in total population. They are as follows: (1) Changes in age distribution; (2) changes in the proportion of the population 14 and over attending school; and (3) the amount of hidden unemployment in the present population that would be available for work if jobs were available. As shown in Section II, this hidden unemployment was estimated as being about 30 percent.

The Census-survival method was used to project the age-sex distribution of the 1970 population. By using this method (82, 131, 132, and 143), it was found that the proportion of males and females 14 to 64 years old in each population target would be as follows:

	Population target, 1970			
	No. 1	No. 2	No. 3	No. 4
Males (14-64)	0.556	0.567	0.581	0.596
Females (14-64).	.571	.577	.585	.593

[11] The U.S. projection is based on a straight-line linear extrapolation of real per capita income from 1950 to 1960, resulting in U.S. per capita income projected to increase from $2,000 (1954 dollars) in 1960 to $2,290 in 1970 (1954 dollars).

[12] $dY = dyP + ydP$; where Y is total income, y is 1970 per capita income, P is 1960 population, and d is the amount of change from 1960 to 1970.

School enrollment was projected by sex for two age groups, under 14 years and 14 to 19 years. The projections were made by increasing the proportions of each of these groups enrolled in school to the average for Kentucky.

As a result of the increasing proportion of persons over 65 and the tendency for teenagers to remain in school, the rate of males participating in the labor force can be expected to decline from about 74 to 70 percent. This rate can be raised back to about 75 percent, however, if the persons presently available for jobs but not employed (hidden employment) are provided jobs. The greatest potential for increasing the number of persons in the labor force at the present time lies in increasing the participation of females. The following tabulations shows the relevant ratios of labor force to population (14 and over).

	Male	Female
United States, 1960	0.75	0.34
5-county study area, 1960	.74	.26
5-county study area, 1970, no change in job availability	.70	.25
5-county study area, 1970, adequate job availability	.75	[1] .34

[1] On the basis of the Adair County Study (58), this would have been higher, but it was limited in this study to the proportion of females in the U.S. labor force.

Net additions to the labor force for the development program consist of those persons considered available for jobs under the conditions of adequate job availability, less those actually employed in 1960.[13]

The available labor force was divided into the categories required by the model, as follows: (1) Managerial (including professional), (2) clerical (including teaching), (3) educated persons available for skilled training, and (4) unskilled. No internal training costs were attached to managerial or clerical positions because, to the extent needed, this type of training was assumed to take place outside the area.

Since the income target is to raise the per capita income to that of Kentucky as a whole, managerial and professional workers were assumed to account for the same proportion of the work force as they did in Kentucky in 1960. This proportion, however, was applied only to the No. 4 population target

[13] Some of these may also become available for jobs as a result of conversions in agriculture.

to avoid possible understatement of available managerial workers in targets 1, 2, and 3 (table 6).

It was assumed for population targets 1, 2, and 3, that the number of managers would be in the same ratio to the number of educated males as in target 4 (i.e., ratio of 31 to 100).[14] This was done to account for the effect on the area's labor force of upgrading the level of education, including the possibility that some unskilled workers in the "old sector" would become managers and skilled workers in the "new sector". By using this method of calculation, the number of managers available in the local labor force is much greater than if the number was calculated as a proportion of the additional labor force.

The number of educated males available for managerial and skilled jobs, i.e., high school graduates, was estimated by assuming that (a) in age groups now over 19 the proportion completing each school level would not be changed by death or migration, and (b) in age groups under 19 the high school graduates would increase in proportion to expected increases in school enrollment. All male high school graduates (not in college), who are not listed as managers or professional workers, were considered as being available for training for skilled positions.

Discrimination by sex is introduced for convenience. Only males are considered eligible for managerial and professional jobs, and only females for elementary and secondary school teaching and clerical positions--provided they are high school graduates. There are undoubtedly some of each sex in the other categories, but the number to move is not estimable, and would not significantly affect the proportion of the labor force in each labor category.

The resulting labor force projections are presented in table 7. Since the Glasgow trade area presently has a notable absence of jobs for skilled workers, it is assumed that skilled positions would have to be filled in the first decade of the development program. Workers would either be imported from other areas or local persons trained for these jobs. Importing workers is allowed in the model in the form of in-commuting, and labor training is explicitly introduced by a training activity. The training activity takes an unskilled worker and transforms him into a skilled worker at an estimated training cost of $1,050.[15]

Note that the declining population in target 1 results in a net decline in males available for jobs. This led us to

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[14] Educated males are considered to have completed 4 years of high school.

[15] Training a skilled worker is estimated to require an average of 2 years of vocational training, or its equivalent, at a current operating cost of $300 per student year. This is estimated at current cost of the vocational program of the Kentucky Department of Education, plus fixed costs for space and equipment of $450 per student (150 square feet per pupil at $30 per square foot, amortized over 10 years. (Based on data in the official files of SRI.)

Table 7.--Estimates of local labor available for 4 population targets, by labor category, 5-county study area, 1970

Labor category	Population target											
	No. 1			No. 2			No. 3			No. 4		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
	2,000 hours per unit			2,000 hours per unit			2,000 hours per unit			2,000 hours per unit		
Managerial.....	[1] 89	--	89	[1] 230	--	230	[1] 348	--	348	[2] 497	--	497
Clerical.....	--	246	246	--	465	465	--	649	649	--	881	881
Educated persons available for skilled training.....	[3] 198	--	[3] 198	[3] 510	--	510	[3] 772	--	772	1,102	--	[3] 1,102
Other.....	-1,046	1,691	645	360	2,154	2,514	1,542	2,543	4,085	1,927	3,033	4,960
Total.....	-759	1,937	1,178	[4] 1,100	[4] 2,619	3,719	[4] 2,662	[4] 3,192	5,854	3,526	3,914	7,440

[1] 31 percent of the men having 4 years of high school who are in the labor force.
[2] Equal to the percentage of labor force in Kentucky in professional and management positions in 1960, i.e., 14.1 percent.
[3] 69 percent of the men having 4 years of high school who are in the labor force.
[4] Interpolation between targets 1 and 4, based on population ratios.

conclude that population target 1 was inconsistent with a feasible development program to increase per capita income in the region by 70 percent in a decade, as will be shown later.

Consumption Targets

Per capita consumption in 1970 was projected by deducting from the per capita income targets described above, 10 percent for income taxes, 7 percent for savings (present U.S. average), and 1 percent for property taxes (southern average in 1955) (114). State sales taxes were not deducted. The results are as follows:

1970 per capita income	=	$1,740
Deductions	=	300
1970 per capita consumption	=	1,440

The difference between 1960 consumption and 1970 is as follows:

1960 per capita income	=	$1,008
Deductions	=	101
1960 per capita consumption	=	907
Difference in per capita consumption	=	533

Table 8 shows how the difference in total consumption associated with each population target was determined.

Table 8.--Total consumption targets, 5-county study area, south central Kentucky

Population target	Change in consumption from 1960 to 1970 for the 1960 population	Total 1970 consumption for the change in population from 1960 to 1970	Total increase in consumption from 1960 to 1970
	1,000 dollars	1,000 dollars	1,000 dollars
No. 1.....	37,535	-6,127	31,408
No. 2.....	37,535	0	37,535
No. 3.....	37,535	8,323	45,858
No. 4.....	37,535	16,648	54,183

Total consumption for each population target was then allocated to each of the domestically producible commodities in the model. The residual represented demand for imports, transformed directly into demand for foreign exchange on

current account. Different sources of information and somewhat different methods were used in determining the consumption targets for individual commodities. In general, the consumption commodities may be considered as being in two groups: nonfood and food, discussed below. Additional targets were established for residential construction, road construction, and government services by special methods, also discussed in this section.

For Nonfood Commodities

1. Total consumption expenditure per southern farm family was reported as $2,840 (114). It is assumed that the relative amounts spent on each nonfood commodity is the same for the families in the Glasgow trade area as for the southern families in the cited study (114). Second, it is assumed that increases in income would be apportioned among the nonfood commodities as the average income is apportioned (i.e., that the elasticity of demand with respect to income is 1).

2. The expenditure data are in terms of value of purchases in 1955 (114), whereas the model requires that consumption targets be in the commodity units of the matrix. Many are physical quantities. It was necessary, therefore, to perform certain operations before the data could be used in the matrix. These consisted principally of the following: (1) Where the commodity categories in the source table did not correspond exactly to categories in the matrix, we had to determine what part of the amount spent on a commodity listed in the table was spent on the commodity designated in the matrix; and (2) to determine quantities consumed, where required, it was necessary to estimate retail prices for 1955 and then divide the value of purchases by these prices.

3. Expenditures on consumer services were determined in (114), but estimates had to be made as to whether these would be domestically produced or imported. All automotive and miscellaneous repair services (C080) were considered to be produced domestically. Location quotients were used for medical expenses, legal fees, school tuitions, and the like.* Banking expenses were allocated two-thirds to domestic and one-third to imports (79), and most other services were considered either all imported (for example, insurance), or all domestic (for example, personal care, recreation admissions, local travel, membership dues, and funeral expenses). As noted elsewhere, these divisions of the services were necessary because domestic and import services were considered as noncompeting activities, with demand for import services going directly into the foreign exchange, current account row.

* Ratio of the percent of Kentucky employment in a given industry in the 5-county study area to the percent of Kentucky income in this area.

4. Consumption per family was transformed into consumption per $1,000 of total expenditure by dividing by the total expenditure of the average southern family, i.e., $2,840.

5. Expenditures for each nonfood item per $1,000 of total expenditure were adjusted upward by a constant, one for each population target. This adjustment was needed because different sources were used to determine food and nonfood expenditures and had to be reconciled (table 9).

Table 9.--Adjustment multipliers applied to the nonfood items, 5-county study area

Population target	Proportion of total expenditure on nonfoods		(3) Adjustment multiplier (2) ÷ (1)
	(1) According to source (114)[1]	(2) According to sources (95) and (122)[2]	
No. 1.....	0.736	0.935	1.270
No. 2.....	.736	.906	1.230
No. 3.....	.736	.880	1.195
No. 4.....	.736	.862	1.171

[1] Source used for deriving individual nonfood consumption indexes.

[2] Source used for deriving individual food consumption indexes.

6. Expenditures on each nonfood item per $1,000 of total expenditure was multiplied by total consumption ($1,000) associated with each population target to determine total purchases of each item.

7. Expenditure on trade was equal to the trade markup per $1,000 on all purchases of goods that would be handled by retail trade, i.e., 58.15 percent of all consumer purchases. It was assumed that all goods locally consumed were purchased through local trade activities, even if the goods themselves were produced elsewhere. The trade markup (tentatively estimated as 29 percent of the retail market price based on the 1947 interindustry study) was deducted from the value of imported goods to avoid double counting.

For Food Commodities

1. In Table 8, consumption was divided into two parts: (1) Increased consumption for the existing 1960 population; and (2) total consumption for the change in population from 1960 to 1970. Food consumption was computed separately

for each group to account for the low income elasticity in food consumption.

2. For each food commodity to be included in the model, and for all food commodities, an income elasticity was calculated on the basis of the elasticities reported in (95). A weighted average of the elasticities for the low income nonfarm families and the medium income farm families was used to compute the elasticity of consumption for the 1960 population in the 5-county study area.[17]

3. The total increase in the amount of each food commodity consumed by the existing population was found by multiplying the average quantity consumed per household, as reported in (122), by the percentage change in consumption of each food commodity.[18] The percentage change in consumption is the product of the income elasticity (i.e., percent change in quantity consumed/percent change in after tax per capita income) times the percent change in after tax per capita income, which has been set at 62 percent for this model.

4. To the total reported in 3, above, the consumption of new families had to be added for population targets 3 and 4. Since it is the total consumption of these additional families that is involved, the average quantity consumed per family reported in (122) was used directly, multiplied by the total new families in the relevant population target.[19]

Final demand targets were also established for three special items not a part of regular consumption:

1. Residential Construction.--This item consists of new construction and repair. Projection of new construction was made by using a linear regression that related the value of residential starts in the United States, by State, to changes in income, changes in population, and income per capita (135, 136, and 142). A satisfactory correlation was found (0.835) using the following equation:

$$Z/P = -63.3 + 277.4\ \dot{Y}/Y + 1300.5\ \dot{P}/P + 38.67\ Y/P,$$

where

Z/P is per capita new residential construction expenditure in year n,

$\dot{Y}/Y$ is change in total income in the area from year n-1 to year n, divided by total income in year n-1,

---

[17] Medium income farm families were used because the increases in income to farmers represent a high degree of commercialization and the transition of the farmers so benefiting to medium income levels.

[18] The number of families, or households, was determined by dividing the population by 3.3, the number of persons per household reported by the Census of Population in the 5-counties in 1950.

[19] Food consumption per household for different population groups, farm, rural nonfarm, all nonfarm, and urban, are found in (122). Consumption data for the rural nonfarm families were used here for the existing population, and consumption data for the southern nonfarm (combined rural and urban) for the new families.

$\dot{P}/P$ is change in population in the area from year n-1 to year n, divided by total population in year n-1,

Y/P is income per capita in thousands of dollars in year n-1.

In target 1, where population is assumed to decline, $\dot{P}/P$ was taken as zero in the equation. Negative effects are not considered for two reasons: (1) In the period considered, observed changes by State were almost all positive; therefore, extrapolation to conditions of negative population change are not warranted for this equation; and (2) a decline in population has the same effect on new residential construction as a zero change in that both create zero demand for new residences.

The value of house repair was added to the goal for residential construction, using (114) to estimate the value of house repair associated with changes in income.

2. Roads.--Road construction is also not generally a part of consumption, yet the annual requirement for road construction must be taken into account in a development program. A Virginia study conducted by the University of Virginia in 1956 provided the basis for projecting road needs in the Glasgow trade area (163). This study showed the changes in motor vehicle use in a rural area in Virginia that resulted from the introduction of a manufacturing plant--exactly the same type of change as was contemplated in this study. In the Virginia study, it was found that a $100 increase in annual income was associated with an increase of 1 vehicle mile per day. This increased motor vehicle use was related to road requirements indicated in the 1954 Kentucky Highway Development Program report, in which it was estimated that road development in the State would cost 1.2 cents per vehicle mile (about 1.4 cents in 1959 dollars). Thus, new road requirements resulting from the increase in income in the area were considered to be as follows:

$$dY/\$100 \times 365 \times 1.4¢ = \text{annual road construction cost.}$$

No consideration is given to road construction to cure existing deficits in the road network in the area under study.

3. Government.--Federal Government expenditures are not included in our model. All other State and local government activities except road construction and maintenance, which are considered separately, are lumped into one vector and provided with a constraint for each consumption case. The level of government activity is assumed to depend upon the size of the population and projected school enrollment corresponding to that population, rather than on increase in income. Thus, in population target 1, the declining population results in no increases in government services, and the constraint is zero. Population target 2 has a special vector in that there are some increases in government services

required for school construction and education only, despite the absence of growth in total population. For population targets 3 and 4, government services were based on the number of employees per 10,000 population (138).

Export Constraints

Export constraints were arbitrarily chosen in the absence of proper market analysis. However, in many cases, a general knowledge of the market aided in determining reasonable constraints for exports to the nearby market (area 1) and the national market (area 2). In other cases, exports to areas 1 and 2 were permitted to expand to the output level of the producing activity operating at one unit and three units of intensity, respectively. The export constraints were varied to determine the effect of such variation on the optimum solution (Section VI).

Conversion Constraints

The constraint on each conversion activity is determined by the amount of the basic resource, such as land or size of herd, that is to be technologically changed in use. The constraints used in the model for each of the conversions are shown in table 10.

Once the model was completed to the point of fully quantifying the equations and activities in the matrix, the information was placed on punched cards. A card was punched for each slack variable and each dummy export commodity. Also, a card was punched for each nonzero item in the matrix. The data deck, consisting of over 4,000 cards, was run on the computer. The results are discussed in Section VI.

Table 10.--Constraints used in the model for each of the conversions

Activity number	Description
CA-1 to CA-5[1]....	Constraint based on 4,046,000 bushels harvested in the 5-county area in 1959 (126).
CA-6 to CA-7[1]....	Constraint based on 13,400 acres of tobacco harvested in 1959 (126).
CA-8[2].....	Constraint based on number of chickens 4 months old and over on farms in 1959 (126) multiplied by 35.5 percent (117), the percentage of chickens in Kentucky that are layers; and adjusted by 40 percent decline in layer flocks based on rate of decline from 1950-60 (126).

See footnotes at end of table.

Table 10.--Constraints used in the model for each of the conversions--Continued

Activity number	Description
CA-9, CA-12 and CA-13[2].....	Constraint based on 46,600 cows in the 5-county area in 1959 (126); proportioned 20 percent market milk herd and 80 percent manufacturing milk herd (17).
CA-10[2].....	Constraint based on number of acres in 1959 used for pasture, excluding woodland (126).
CA-11[2].....	Constraint based on 17,400 head of beef feeder heifers in 1959 (126).

[1] See table 3.
[2] See table 4.

VI RESULTS OF COMPUTER RUNS

The flexibility of linear programming techniques allows the analyst to study the effects on the development program of variations in the parameters of the model. For example, variations in export constraints will show changes in the foreign exchange cost of a given program; variations in competitive wage rates will show what industries are most sensitive to wage shifts; variations in consumption targets will show the differences in programs necessary to meet these targets, etc. By successively varying prices or wages, demand and supply schedules can be constructed. In general, the ability to make successive iterations with the model at relatively modest computer costs is a major feature of this model for development planning.[20]

In this study, seven runs were made. They were as follows:

1. R013-1. This trial is referred to as the "basic solution." It has the following characteristics: (1) Consumption targets are for population target 4, the largest increase allowed; (2) if labor has to be imported, rates are $10,000 for managers, $6,000 for clerical and skilled workers, and $3,000 for unskilled workers; and (3) seasonal use of unskilled labor is provided for. Other specific targets and constraints in this program concern consumption, government services, roads, housing, export demand, local labor availability, and natural resource use.

2. R013-2. Same as R013-1, except that seasonal use of unskilled labor is disregarded, and only total use is considered.

3. R013-3. Same as R013-1, with wage rates for imported labor changed as follows: Managerial rate is raised from $10,000 to $12,000; skilled labor rate is raised from $6,000 to $6,500; and unskilled labor rate is reduced from $3,000 to $2,500.

4. R013-4. Same as R013-1, with wage rates for imported labor changed as follows: Managerial rate, $15,000; skilled labor rate, $7,000; and unskilled labor rate, $2,500.

5. R016-1. Same as R013-1, except that certain constraints on exports to area 2 are increased by 60 percent; the constraint on tobacco allotment is doubled; and the constraint on stumpage is increased by 50 percent.

[20] Successive trials took 10 to 15 minutes each; this time can be reduced by choosing units for the commodities that reduce the range of sizes in a column vector.

6. R012-1. Same as R013-1, except that the consumption target is based on population target 3.

7. R011-1. Same as R013-1, except that the consumption target is based on population target 2.[21]

Within the financial limits of this project it was possible to analyze the results of only one trial, the basic solution; these results are discussed below.

Basic Solution R013-1

The basic solution requires a net outside financing of $29,700,000 annually, of which $20,400,000 is used for financing current account expenditures, and $9,300,000 is used for financing capital expenditures. The income and product account resulting from this program for the last year of the 10-year program is as follows:

Uses of income	Million dollars	Sources of income	Million dollars
Consumption	54.9	Wages and salaries to local workers	30.7
Domestic investment	11.2	Rents and profits	11.5
Government services	6.4		
Net exports	-29.7		
Total uses	42.8		
Less: unemployment	-.6		
Total income	42.2		42.2

Total fixed investment required for the program is as follows:

	10th year	10-year total
	Mil. dol.	Mil. dol.
Domestic investment	10.0	50.0 (approx.)
Imported investment	9.3	37.2
Road construction	3.2	21.3 (approx.)
Total	22.5	108.5

The imported investment content of domestic investment and road construction, such as for road building equipment, were deducted to avoid double counting.

[21] After the matrix was constructed, it became evident that the supply of managers and skilled labor in the area would be so inadequate using the No. 1 population target, that a development program would be impractical; therefore, we used another population target.

The income created by the fixed investment is as follows:

	Mil. dol.
Income for area residents	42.2
Income for incommuting labor	5.6
Total	47.8

Thus, the output/capital ratio for the program is 0.44 (47.8/108.5), compared with 0.35 to 0.40 for the United States (A3, p. 244).[22]

The amount of income created and the net export balance in the regional development program are strongly affected by the constraints on exports. Income could be increased and the negative foreign balance decreased by relaxing the constraints on exports that are profitable and expanding their production. Although the export constraints adopted in the model are arbitrary, they are based on our judgment of attainable export goals in the 10-year period. We believe further expansion of exporting activities is more speculative. Nevertheless, the possible effects on the program of further expanding those activities selling profitably in the national market (i.e., exporting to area 2) are worth considering.

Only seven commodities showed profits in sales to area 2. They were: (1) Other hand tools; (2) men's socks; (3) cotton housedresses; (4) rough lumber No. 1 common or better; (5) wooden handles; (6) brake linings; and (7) frozen snap beans. Therefore, for the basic solution program, a second run was tried in which the export demand to area 2 of these commodities was increased by 60 percent. (This second run is designated R016-1).

Wages and salaries paid to labor is the product of the quantity used of each kind of labor times its shadow price summed for all kinds of labor. The quantity used of each kind of labor in R013-1 is shown in table 11. As shown previously (fig. 1), additions to the supply of local labor result from growth of the labor force, hidden unemployment, and job training (column 1) and by technological change in agriculture (column 3). The supply of labor is made equal to the demand by the export, i.e., unemployment and import of labor.[23]

Wage disbursements are found by multiplying the quantity of labor used in 2,000-hour units by the wages per unit for each type of labor. Wage disbursements to local labor only are found by deducting the value of disbursements to imported

[22] Since the emphasis in our model was on agriculture and labor intensive industries, an above average ratio of output to capital must be expected.

[23] An export activity for labor is necessary so that the existence of unemployment does not force the price of labor (in the category having unemployment) to zero. This would be the price assigned to the linear programming solution to any local resource not fully utilized.

Table 11.--Labor use in the basic solution (R013-1)

Type of labor use	Local labor			Imported labor	Total labor used
	Available	Exported (unemployed)	Produced by conversion		
	2,000 hours per unit				
Managers	497.0	--	--	168.8	665.8
Clerical labor (L002)	881.0	--	--	54.3	935.3
Skilled labor (L003)	--	--	--	587.2	[1] 587.2
Educated persons available for skilled training (L011)	1,102.0	--	--	--	[1] 1,102.0
Unskilled labor (L004):					
Jan. - Feb. (L005)	[2] 826.6	-99.9	125.1	--	851.8
Mar. - Apr. (L006)	826.6	--	79.3	--	905.9
May - June (L007)	826.6	--	288.4	--	1,115.0
July - Aug. (L008)	826.6	--	126.3	22.1	975.0
Sept. - Oct. (L009)	826.6	--	89.2	9.6	925.4
Nov. - Dec. (L010)	826.6	-215.6	285.1	---	896.1
Total labor	7,439.6	-315.5	993.4	842.0	8,959.5

[1] Total number of skilled laborers used is 1,689.2 (587.2 + 1,102.0).

[2] To determine the amount of unskilled labor available, the number of educated persons used in training for skilled jobs, L011, is deducted from the number of unskilled laborers available shown in the computer runs L004-L010.

labor, in this case $5.6 million, from total wage disbursements, in this case $36.3 million. Thus, local wage disbursements total $30.7 million per year.

Comparison of Foreign Exchange Balances and Industrial Composition of the 7 Computer Runs

Insight into the stability of the solution, the sensitivity of various aspects of the program to changes in the parameters, and the marginality of certain manufacturing and agricultural activities can be achieved by analyzing alternative runs of the model.

Full analysis of income generation and labor balance was not made for the six runs subsequent to R013-1. However, an analysis was made of differences in the foreign exchange balances among the solutions and in the industrial composition of the optimum programs. Table 12 presents the foreign exchange balances on current and capital account for the seven runs.

The main conclusion drawn from this table is that the biggest causes of variations among the solutions are changes in consumption demand for imported goods and services (F001) and changes in the value of imported labor. The value of imported labor moves inversely with the size of the population projection; that is, it is the lowest for R013, which relates to population projection 4 and highest for R011, which relates to population projection 2. The relaxation of export and resource constraints (R016) makes the program cheaper in foreign exchange by $2.1 million.

Significant differences showed up in the computer runs in foreign exchange requirements on capital account, as well as on current account. Capital account requirements for R011-1 are 18 percent less than for R013-1. Part of this difference is due to less investment needed for local consumption because of the smaller population increase assumed for R011-1, but also part is due to less export. Dairying, hog raising and slaughtering, and manufacturing boxes, shooks, and pallets were all adversely affected by reduced exports in the lower population runs. These results should be more carefully analyzed to determine which constraints entered into the lower population targets to adversely affect these activities.

As one would expect, the wage changes that make imported managers and skilled workers more expensive and unskilled workers less expensive shifted the solutions for R013-3 and R013-4 toward more agricultural than manufacturing activities. This was especially true for R013-3, which assumed lower skilled and managerial wages than R013-4, but the same unskilled wages. The lower unskilled wages expanded freezing strawberries, manufacturing milk production, and raising snap beans for processing in R013-3, but the much higher managerial and skilled wages contracted wood products industries and hog raising from the basic solution in R013-4, and no additional dairying in R013-3.

Table 12.--Comparison of foreign exchange balances for the computer runs

Column number							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Computer run	Net foreign exchange on current account (ZF001)	Value of imported labor	Value of exported labor (unemployed)	ZF001 for goods and services	Net foreign exchange on capital account (ZF002)	W (5) + (6)	Fool for final consumption
	1,000 dollars						
R013-1.....	20,396	5,632	631	15,395	9,292	24,687	25,280
R013-2.....	19,576	5,343	--	14,233	9,180	23,413	25,280
R013-3.....	20,342	6,249	504	14,597	9,133	23,730	25,280
R013-4.....	21,201	6,164	618	15,655	8,964	24,619	25,280
R016-1.....	17,605	6,562	421	11,464	9,876	21,340	25,280
R012-1.....	17,662	7,010	269	10,921	8,626	19,547	21,580
R011-1.....	14,394	8,195	84	6,283	7,563	13,846	17,880

In general, the wage changes from R013-1 to R013-3 improved somewhat the foreign exchange balance on current account and possibly some increased income because of the increased exports. Further increases in wage costs in R013-4 probably resulted in some decreases in exports and in income.

Eliminating the seasonality of labor in R013-2 improved the foreign exchange balance on current account and caused expansion of some agricultural activities.

Relaxing export constraints in R016-1 considerably improved the foreign exchange balance on current account, reducing the deficit on current account by almost $4 million, or 25 percent. The $0.6 million rise in deficit on capital account represents increased investment and indicates increased income over the basic solution.

In general, the industrial composition of the program shows considerable stability. The six major manufacturing complexes, the five new agricultural complexes, and the seven conversions--all of which were included in the basic solution (R013-1)--were also included in the other six runs. Within the complexes, there were some interesting specific variations among the runs.

The manufacturing complexes are: (1) Hand tools, I001 and I002; (2) apparel, I004 to I007; (3) lumber and wood products, I008 to I019; (4) concrete products and building materials, I020 to I026; (5) food processing of crops, I032, I034 to I037; and (6) food processing of dairy and livestock products, I038 to I047 and I049 to I053. A discussion of each of these follows.

1. Hand tools.--The production and export of the hand tools are profitable in all seven runs. Production is carried to the maximum export constraint; these constraints were changed for R016-1.

2. Apparel.--All four apparel industries are included for production in all seven solutions. However, there are no exports in any of the solutions of men's underwear (C048); exports of men's work clothes (C049) are confined to area 1 for all runs except R013-1 and R013-2.

3. Lumber and wood products.--In the basic solution, all the wood products industries are included except production of finished lumber (I010 and I012). Paint and varnish brushes (C062) are produced only for local consumption. Boxes and shooks (C058), pallets (K002), bedroom, dining room and living room furniture (C063, C064, C065) are exported to area 1 only. Both local stumpage and imported logs are used to produce rough lumber. In the high-wage run (R013-4), exports of boxes and shooks, pallets, and living room furniture are eliminated, and consequently, production of industries I013 and I019 are curtailed. In run R016-1, export

constraints are relaxed on rough lumber (C052 and C053), wooden handles (C060) and brooms (C061), and, consequently, production of these commodities increases to the new limits in this run. In the low population projection run (R011-1), the composition is the same as in the basic solution, except that exports of boxes and shooks and pallets are confined to area 1; thus, production of I013 is lower.

4. Concrete products and building materials.--All these industries are in all seven solutions. Production of dry-mix concrete (C069) is sufficiently profitable to export it in all solutions.

5. Food processing of crops.--Production and export of soybean oil and meal is highly profitable, based on local supplies of soybeans. The output of the soybean oil and meal plant (I032) is constrained by the amount of land available to raise soybeans. This varies in each solution depending upon the amount of available new land (C086) used for expanded soybean production.[24] Freezing is profitable, and a combination of I034 and I036 is used by each run. In runs R013-2, R013-3, and R013-4, frozen strawberries are profitably exported, thus more of I036 and less of I034 are used than in the basic solution. In run R011-1, I036 is eliminated.

6. Food processing of dairy and livestock.--In all runs, market milk is produced only for local consumption; manufacturing milk is processed into ice cream, condensed skim milk, and cottage cheese in industries I046 and I047 for local consumption and export. Exports to area 2 vary among the runs with the profitability of manufacturing milk herd expansion, i.e., more area 2 exports for ice cream and cottage cheese in runs R013-2 and R013-3 and less in runs R012-1 and R011-1 than in the basic solution. Hog slaughtering (I049) is included in all runs, constrained by the export potential of lard in the basic solution and in R013-2 and R013-3, but with exports less than this constraint for the other runs. Beef is slaughtered in all runs in activities I051 and I053. In runs R013-2 and R013-3, more cull cows are slaughtered because of expanded dairying activities.

The agricultural complexes included in all solutions follow: (1) Tobacco (A001); (2) truck crops (A002 to A004, A007 to A010); (3) dairying (A013 and A014); (4) hog raising (A017 and A018); and (5) other crops (A011, A012, and A019).

1. Tobacco.--Tobacco raising is a highly profitable activity in all seven runs, expanding to the limit permitted

[24] Soybean production varies inversely with the requirements for hay, which has first claim on new land in the model.

by a 6 percent increase in allotment for all runs except R016-1, which was permitted to expand by 12 percent.

2. Truck crops.--In the basic solution, strawberries, lima beans, and okra are raised for the frozen food plant; strawberries for processing are also exported fresh. Snap beans are raised only for the fresh market, while peas are not raised at all.[8] The production of strawberries is sensitive to changes in assumptions, declining in R013-2, R013-3, and R011-1, and increasing in R013-4. Production of snap beans for processing (A003) appears only in R013-2 and R013-3.

3. Dairying.--Production of manufacturing milk in A013 appears in all seven runs, although it is expanded beyond the basic solution in R013-2, R013-3, and R013-4, while it is expanded less than in the basic solution in R012-1 and R011-1. Production of market milk in A014 is not included in the solution in any run.

4. Hog raising.--In the basic solution, producing both feeder pigs and market hogs are included, with feeder pigs going both to activity A018 and to exports. Expanding activity A017 is constrained by the export capacity for cull sows (C002). Both hog production activities are expanded less in R013-4 and R012-1 than in the basic solution. In run R011-1, expanding the production of feeder pigs is more restricted than in the basic solution, and production of market hogs (A018) is eliminated.

5. Other crops.--Expanding production of three other crops, competes for available new land (C086). These crops are soybeans, hay, and pasture. New pastureland appears only in runs R012-1 and R011-1, when expansion of hay and soybeans is not adequate to absorb all the 100,000 acres of crop and pastureland considered available for new crops. Hay production is the most important use of the new land, expanding to the extent required by the increased livestock and poultry enterprises. Soybeans are grown for the soybean oil and meal mill.

Two sets of agricultural activities that were included in the model but not entered in any of the solutions are expanded poultry and cattle and calf production. Some of these enter in a limited way through conversion, as discussed a little later.

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[8] The reason is that the price differential for export is greater than the cost differential in the model. However, basing a frozen food plant on raw materials that must be brought from any appreciable distance (over 50 miles), is apt to be unsuccessful, because of difficulties in quality control that are not reflected in the linear programming model.

The seven conversion activities listed below were included in the model. All are included in all solutions. They are as follows: (1) Corn (CA001 to CA005); (2) tobacco (CA006 and CA007); (3) commercial layer flocks (CA008); (4) manufacturing milk herds (CA009); (5) pasture (CA010); (6) cow-calf (CA011); and (7) market milk herds (CA012 and CA013).

Only in the case of corn conversion are there any significant differences among the runs. The mechanization of corn, as represented by activities CA001 and CA004, is shown to be of marginal value in the model and therefore sensitive to changes in the assumptions. Runs R013-1 and R016-1 include partial mechanization. Mechanization is complete in runs R012-1 and R011-1. It does not occur in runs R013-2, R013-3, and R013-4. In all seven runs, additional requirements for corn by the expanded livestock enterprises are met by adding fertilizer to existing corn acreage to increase corn yields (CA004 and CA005).

Mechanization of tobacco acreage is somewhat profitable and occurs in all trials. Commercial layer flock, manufacturing milk herd, and cow-calf conversions are all very profitable and occur in all runs.

Market milk herd conversion is not in itself profitable, but occurs in all runs. This conversion activity supplies the market milk for the local fluid milk plant. Since the herds already exist, improving these herds was found to be cheaper than importing milk.

Pasture conversion is not profitable but occurred in all solutions because of the need for more pasture units. New land was not available for pasture in most solutions because it is absorbed by soybean and hay crop expansion.

Where the conversion activity is profitable but there is no expansion of new enterprises indicated in the solution, it may be that the truly economic solution would be to eliminate the entire enterprise. However, our model permits only positive changes. The solution says in effect, "the present level of enterprise in these activities is very inefficient and conversion is better than continuing at the present levels; however, if the activity does not now exist, there is no profit in establishing it."

VII GENERAL EVALUATION

The results obtained from application of the model to the Glasgow trade area are summarized in Section VI. The resulting industrial composition of the various solutions was given along with their foreign exchange requirements, labor demand, and other information. Given these results, what can be said about their implications to economic development in the area? The first part of this section deals with that question. The other two parts cover implications of the model for general use and certain modifications in the data or model which might be desirable.

Evaluation of the Prospects for a Development Program in the Glasgow Trade Area

The most important question in establishing a public policy, is whether an overall development program is worth undertaking for a given area in terms of economic costs and benefits. The answer to this question is a matter of policy decision. It is not to be found in the solution derived from the planning model. However, the solution does provide important information to the decision maker. The two items of most interest are: (1) The relationship between foreign exchange requirements, both on current and capital account, and the income generated by the program; and (2) the labor balance.

The deficit in capital accounts for a development program for the Glasgow trade area is not excessive. A total 10-year fixed investment for the R013-1 program of $37 million (4 times the 10th year requirement of $9.3 million) by outside agencies (e.g., public and private) will increase annual income about $48 million. In addition, the outside investment is expected to bring about local capital formation of $71 million. These relationships are acceptable. On the other hand, the annual deficit in the foreign exchange balance on current account for goods are services of about $15 million is high (table 12). On the basis of the activities that have been investigated in the present program, the per capita income goal of the program appears to be ambitious relative to the costs in foreign exchange. In other words, self-sustaining growth has not been achieved by the end of 10th year.

However, this does not mean there is no hope for this area. It means that efforts must be made to alter the present program in the direction of a lower deficit in the foreign exchange balance on current account. Run R016-1 shows that this account could be reduced by relaxing the constraints on profitable exports. The way in which the export constraints used in this program are constructed makes some of them conservative. Those commodities which do not appear profitable to export to area 2 can usually be disregarded as having

strong export potential. But those which show to be profitable for area 2 may warrant further investigation as to their ultimate potential.

Another possibility for altering the foreign exchange balance should be considered. Because of the way the model is constructed, all imports required for the consumption targets are taken into account. However, only the exports of those industries included in the model are taken into account. Thus, there may be export possibilities not investigated in this model. This bias in the results may tend to overstate the balance of imports over exports on current account.

Finally, the possibility of a lower income goal may have to be considered. A growth rate of 5.6 percent per annum may be too ambitious and may have to be lowered to 4.5 or 5.0 percent. Whether or not this will yield a more favorable income/capital ratio would need to be determined. In other words, perhaps the area can achieve a self-sustaining growth rate which is less than the original goal of 5.6 percent, but considerably above what it is presently experiencing. Also, it may take such an area more than 10 years to reach self-sustained growth.

Another conclusion that comes out strongly from the operation of the model is that there is a significant scarcity of persons available for managerial and skilled positions. Unless the region in which the development program is to be implemented can import a large number of persons in these categories, or the area is expanded to include a larger, more diversified labor force, it will not be possible to carry out the program. Since inland rural regions have difficulty importing such people, the region may have to be enlarged to ensure the needed labor resource base. Moreover, a national program of increasing the educational level of the working and potential working population is a necessary precondition to growth of underdeveloped areas.

The stability of the composition of the program over all runs should be considered in planning the development of an area. The seven runs examined in this study by no means constitute a complete set of all possible runs. It is quite possible that other profitable activities were omitted from the program. Nevertheless, this stability factor indicates that the general composition of the program is focused in the right direction and tends to increase confidence with the program results. The cost of the development program, in terms of foreign requirements, varied considerably among solutions. Most of this variation, however, was due to changes in the size of the population projection which resulted in a variation in consumption demand for imported goods and services and the value of imported labor (table 12). Variation in the cost of the program is shown to be more attributable to the magnitude of the program rather than its composition. With the composition of the program pretty well established, the basic plan is set forth, and agencies can proceed in an organized

manner to develop the detailed follow-up studies that are required for the formulation of action programs for specified areas.

Implications for General Application of Activity Analysis Planning Model

Most of the features of the model developed in this study have been discussed in previous sections. However, there are a few additional points of interest which need to be considered regarding the implications of the overall model for general use. The structure of the model, or the degree of modification of the present model, depends upon the structure of the area being studied and the objective of the analysis.

The mathematical formulation of the exact model will depend upon the structure of the economy of the area. When one moves from a predominantly rural area with little industrial base, such as the Glasgow trade area described in an earlier section, to a more urbanized area, the technological matrix of the model must be expanded to include a larger number of industries. One must know what industries are technically possible in the area. Once this expanded matrix has been prepared for a specific area, the model becomes semioperational in many other similar areas, since the technological coefficients for many industries do not vary significantly among areas. From this standpoint, the cost of preparing such a matrix can be spread over many projects. When one studies less agriculturally based areas, there may be need for including conversion activities for nonagricultural industries.

In a very poor agricultural economy, which has little or no potential for industrial development, the most important means for raising income is through increasing farm incomes. In addition, some institutional requirements should be provided to enhance the mobility of the unemployed and underemployed, such as education, vocational and technical training, and job information services. Some of these rural areas may have potential for recreation enterprises or even recreation complexes. This possibility should be considered and allowed for in the programming procedure.

Adaptability and Additional Uses

The basic model developed and applied here lends itself very well to the modifications necessary in meeting varying conditions among areas. Extensions and adaptations of the model are possible at the present time to include a large degree of flexibility; such as a sensitivity analysis on the objective function, the restriction set, and the resource set (A7). Selected parameters in the model can be varied over a whole range of values. By making these changes and recomputing the solutions, much can be learned about the sensitivity of planning requirements to changes in economic phenomena or the consistency of economic goals under varying resource structures. For example, often agencies in the U.S.

Department of Agriculture have been called upon to estimate the effects of changes in various programs, such as price support and land retirement, on the economies of certain rural areas. Usually, these requests require comprehensive answers on short notice. The availability of a comprehensive model of a complete area economy would permit mutually consistent answers to a variety of questions, or to the same question in a variety of situations, or in different years.

The possibilities for testing various alternative structures is almost unlimited. Some of these were demonstrated in the applied sections of this report. A few other such possibilities that are particularly important are as follows:

1 How would changes in the amount and age distribution of net migration affect the size and nature of the labor force, thus, the shadow price of labor, and the resulting allocation of activities in the model? Is there a maximum amount of net outmigration that is consistent with any reasonable expectations of improving per capita income?

2 How would changes in the level of education of the local population affect the availability of persons for training for skilled positions, and the likelihood of industries that are heavy users of skilled laborers being identified in the model solution as suitable for the area?

3 How would changes in the projected per capita income affect the composition of consumption and the selection of industries in the model?

4 How are government budgets affected by differences in the income projections in the model solution?

5 How would changes in the seasonal pattern of industrial operations change the activity mix in the solution, especially in the choice between agricultural and industrial activities?

For each of these questions, a schedule can be set up involving a series of values of the relevant parameters and constraints, and the model may be run for each thereof, providing a schedule of solutions. These schedules will show how sensitive the solution is to various economic phenomena.

Because the model is quite flexible, resources which delay development prospects can be identified and the effects of changes in these resources evaluated. Such information is important to planners in that it allows them to redirect the development program and prevent gross errors in planning.

In addition to providing a development program in an aggregate sense for an area as a whole, the linear programming tool provides guides to investment decisions by individual entrepreneurs. In contrast to other methods of analyzing

area development programs, linear programming produces as a part of the solution tests of efficiency in the form of shadow prices. These tests could serve as guides for decisions concerned with either establishing branch plants or developing new enterprises. An important feature of the price solution is that it serves to direct the "type" of investment which should be made. It is usually a more serious error to select the wrong type of investment than to be in error as to the amount of capacity. The latter error is more likely to be corrected over time through increased demand.

Evaluation

A criterion of evaluation of a model such as the one developed in this study is not easily established. Either of two criteria are desirable, namely, (a) that it has been tested through implementation, or (b) that it can be compared with the results from an equivalent study using conventional techniques of analysis. The former requires an elapse of time and is therefore not a possibility for a new technique. As to the latter, there is really no alternative study for comparison. This model generates results for a wide range of industries, and all are derived simultaneously. Results from the use of conventional techniques are not likely to cover such a wide range and usually do not take the interdependency of activities into account.

Many successful applications of the linear programming technique have been made. Most of them were for resource allocation problems of single industries or firms. We do not know at this time just how much these methods can contribute to policymakers concerned with area economic development.

Suggestions for Improving Data and Methodology

The methodology developed for this study appears to be a powerful tool for regional development planning and planning evaluation. However, this methodology is pioneering and experimental in nature, and much needs to be done to improve it. Some of the areas where improvement can be made are suggested below. The first four relate to the data required and the last two to the model itself.

1. A more convenient and simple system of designating commodity units should be devised, giving consideration to the range of unit size that can be expected to be encompassed in an activity vector. By minimizing this range, the computing time for successive iterations of the model can be reduced.

2. The industry profile approach to providing basic data for industrial activity vectors should be vastly expanded. The present project could not have been carried out without the use of the ICA-AID industry profiles and fact sheets (159, 160, and 161). However,

better data are needed in which nonmaterial inputs are more carefully defined and analyzed, and in which economies of scale and alternative techniques of production are considered. In addition, many sectors, such as electronics, are not covered by any satisfactory sources of data.

3. It is probable, though not certain, that more disaggregation of the service sectors is desirable for development planning. Research is needed to determine the optimum amount of disaggregation of the service sectors that is desirable and possible. Certainly, more disaggregation would help to identify service sectors that have import competitors or that have export potential (for example, recreation and tourism).

4. Better integration of the program with the existing economy of the region could be achieved by relaxing the assumption that the existing economy is in balance at full utilization of capital. In this way, possibilities for expanding existing sectors through better utilization of capital and import substitution could be investigated.

5. A dynamic element could be added to the model by providing for reinvestment of depreciation funds and by putting the model solution on an annual basis so that the solution in year n-1 becomes an input for the solution in year n.

6. Experimental investigation should be conducted to find satisfactory methods for including allowance for random variability of key parameters.

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APPENDIX A.--ACTIVITY VECTORS IN THE REGIONAL DEVELOPMENT MODEL
Description and Sources

Activity Number	SIC Code	Activity	Description	Sources[1]
I - MANUFACTURING INDUSTRIES				
I-1	3423	Farm hand tools	Hay fork, digging fork, rake, mattock hoe, planter's hoe, mattock spade, pick, shovel, and machete.	161c
I-2	3423	Other hand tools	Hammer, screw driver, pliers, monkey wrench, open-end wrench, tin snips, and wrecking bars from purchased handles.	160l
I-3	2653	Corrugated fiber boxes	Corrugated fiber boxes.	159f, 160l
I-4	2252	Men's socks	Men's short cotton knit socks, 2-shift operation.	161f
I-5	2322	Men's underwear	Set of a cotton knit brief and "T" shirt.	161g
I-6	2328	Men's work clothes	Sets of denim work pants and chambray work shirts.	160n, 160o
I-7	2361	Cotton dresses	Cotton housedresses.	161b
I-8	2411	Logging	Hardwood Logs.	Labor: 170
I-9	2421	Sawmill	Produces rough lumber: 30% No. 1 common or better; 70% less than No. 1 common.	129, 130, 160q, 160r
I-10	2421	Finished lumber	Produces finished lumber: less than No. 1 common.	129, 130, 160q
I-11		Farm building & farm lumber construction	For construction and repair of barns and other farm capital requiring lumber, using rough and finished lumber less than No. 1 common.	SRI
I-12	2426	Hardwood dimension lumber & flooring	Rough lumber No. 1 common or better; produces 53% flooring; 30% dimension, and 17% slabs and edgings.	129, 160m, 170, 160q
I-13	2441	Wooden boxes, shooks, & pallets	Rough lumber less than No. 1 common; produces 70% pallets and 30% unsanded nailed wooden boxes and shooks.	46, 61, 121, 159b, 160d, 170, 171
I-14	2861	Charcoal	Bulk charcoal made from slabs and edgings.	103, 121
I-15	2499	Wooden handles	Wooden handles for brooms, brushes, pumps, and tools made from finished lumber, less than No. 1 common.	61, 170, SRI
I-16	3991	Brooms	Brooms from purchased handles.	61, 170, 159d
I-17	3991	Paint & varnish brushes	Paint and varnish brushes (1 to 6 inches) from purchased handles.	161h
I-18	2511	Bedroom & dining room furniture	Set of one bedroom suite (3 pieces) and one dining room suite (8 pieces) from dimension lumber, No. 1 common or better.	77, 160c
I-19	2512	Overstuffed furniture	Set of one living room sofa and two chairs made of wooden frames (rough lumber No. 1 common or better) steel springs, cotton padding, and fabric cover.	77, 160p
I-20	3241	Cement	Portland cement, 3-shift operation.	159e
I-21	3271	Concrete blocks	Lightweight aggregate hollow concrete blocks in standard unit of 8" x 8" x 16".	160g
I-22	3272	Concrete pipe	Plain bell and spigot pipe 4" to 24" diameter, reinforced bell and spigot pipe 12" to 36", and plain and reinforced tongue and groove pipe 12" to 36".	160h
I-23	3272	Ready-mixed concrete	Ready-mixed concrete	160j
I-24	3295	Sand, gravel, & limestone	Sand, gravel, and limestone.	8, 60, 144, SRI
I-26	2951	Asphalt paving material	Asphalt paving material.	160a

See footnote at end of table.

Activity Number	SIC Code	Activity	Description	Sources[1]
I-27	3585	Cold storage installation	Manufacture and installation of cold storage units equipped with an electric cooling system with motor.	16, 161i
I-28	3691	Automobile batteries	Lead acid automobile storage batteries.	159a
I-29	3714	Brake lining sets	Set of 8 brake linings for automobiles and light trucks.	160a
I-30a	3872	Fertilizer mixing	Mixing of a variety of nitrogen, phosphorus, and potassium fertilizers. Plant activity calculated from mix of: 44% 5-10-10 and 56% 10-15-10.	7, 161d
			I-30b is 11% of the commodity unit.	
I-31	2042	Animal feed pellets	Mixed feed pellets for livestock and poultry, 3-shift operation.	86, 161a
I-32a	2092	Soybean oil & meal	Crude soybean oil and soybean meal, 3 shifts per day, 300 days per year.	15, 161j
			I-32b is 25% of the commodity unit.	
I-33	2051	Bread bakery	Bread and other bakery products (i.e., cakes, rolls, and pastries) delivered.	129, 159c
I-34a	2037	Frozen snap beans, lima beans, & peas	Packed 50% in retail pack and 50% in bulk pack for institutions; produces 50% frozen snap beans, 30% frozen lima beans, and 20% frozen peas.	Seasonality: {67, 94, Size of export {36,78,94,166 Market: 164
			I-34b is 33% of the commodity unit.	
I-35a	2037	Frozen snap beans	Packed 50% in retail pack and 50% in bulk pack for institutions.	Seasonality: {67, 94 Size of export {36,78,94,166 Market: 164
			I-35b is 33% of the commodity unit.	
I-36a	2037	Frozen snap beans, okra, & strawberries	Packed 50% in retail pack and 50% in bulk pack for institutions; produces 45% frozen snap beans, 37% frozen okra, and 18% frozen strawberries.	Seasonality: {30, 67, 94 Size of export {36,78,94,166 Market: 164
			I-36b is 33% of the commodity unit.	
I-37a	2037	Frozen snap beans & strawberries	Packed 50% in retail pack and 50% in bulk pack for institutions; produces 72% frozen snap beans and 28% frozen strawberries.	Seasonality: {30, 67, 94 Size of export {36,78,94,166 Market: 164
I-38	2026	Fluid milk	Preparation of fluid milk for retail and institutional sales--delivered.	{20, 63, 83, {120, 21, 24, {37
			I-37b is 33% of the commodity unit.	
I-39	2026	Cream & powdered skim milk	52% cream and 48% powdered skim milk.	84
I-40	2026	Condensed skim milk & cream	74% condensed skim milk and 26% cream.	84
I-41	2026	Cottage cheese & cream	69% cottage cheese and 31% cream.	84
I-42	2026 2021	Powdered skim milk & butter	66% powdered skim milk and 34% butter.	84
I-43	2026 2021	Condensed skim milk & butter	85% condensed skim milk and 15% butter.	84
I-44	2026 2021	Cottage cheese & butter	82% cottage cheese and 18% butter.	84
I-45	2024 2026	Ice cream & powdered skim milk	83% ice cream and 17% powdered skim milk.	84
I-46	2024 2026	Ice cream & condensed skim milk	61% ice cream and 39% condensed skim milk.	84
I-47	2024 2026	Ice cream & cottage cheese	67% ice cream and 33% cottage cheese.	84
I-48	5044	Packing & marketing eggs	Grading and packing eggs: 50% packed loose and 50% packed in retail containers--delivered.	90, 91

See footnote at end of table.

Activity Number	SIC Code	Activity	Description	Sources[1]
I-49	2011	Hog slaughtering	Slaughtering of market hogs and cull sows and veal calves and production of fresh pork cuts (16%), cured pork cuts (28.6%), sausage (12%), and lard (15%).	Product breakdown: 113, 161e
I-50a	2011	Cull dairy herd slaughtering	Slaughtering of 44% veal calves and 56% cull cows from dairy herd producing beef (19.6%), veal carcasses (9.7%), and meat byproducts (50.6%) I-50b is 40% of the commodity unit.	42, 62, 168
I-51a	2011	Cattle slaughtering	Slaughtering of fat steers and heifers, average weight of 900 lbs, producing beef carcasses (59%) and meat by-products (20%). I-51b is 40% of the commodity unit.	42, 62, 168
I-52a	2011	Cull cow slaughtering	Slaughtering of cull cows from feeder herd, average weight of 900 lbs, producing beef carcasses (25%) and meat by-products (56%). I-52b is 40% of the commodity unit.	42, 62, 168
I-53a	2011	Cull dairy herd slaughtering & cattle slaughtering	50% each of I-50 and I-51. I-53b is 40% of the commodity unit.	42, 62, 168
A - AGRICULTURAL ACTIVITIES				
A-1		Tobacco	Burley tobacco--average yield 1750 lbs/acre 1a - Mechanized 1b - Present mix (56% horse, 44% mechanized) 1c - Horse.	27, 35, 85, 106, 119, 2, 17, 93, 97, 101, 12, 87, 89
A-2		Strawberries	Hand harvested 2a - High efficiency: yield 3.35 tons/acre 2b - Low efficiency: yield 1.08 tons/acre.	6, 17, 27, 31, 89, 11, 65, 70, 71, 72, 39
A-3		Snap beans for processing	Hand harvested 3a - High efficiency: yield 3 tons/acre 3b - Medium efficiency: yield 1.8 tons/acre.	Fertilizer: 27, 105 Labor: 89 Other: 27 Mechanization: 108 Other: 34
A-4		Snap beans for fresh	Hand harvested 4a - High efficiency: yield 3 tons/acre 4b - Medium efficiency: yield 1.8 tons/acre.	Fertilizer: 2, 27 Labor: 89 Other inputs: 27 Mechanization: 108 Other: 34
A-5		Broilers	3-1/2 lb birds raised from chicks Scale: 5a - Specialized commercial broiler raising; requires managerial input of 1/2 day per week 5b - Farm integrated.	Capital: 27 Variable inputs: 154 Labor: 89 Other: 34
A-6		Commercial laying flock	Scale: 6a - Good productivity: specialized 5,000 hen flock, 20 doz eggs/hen 6b - Fair productivity: farm integrated 1,000 hen flock, 17.5 doz. eggs/hen.	Variable inputs: 154 Labor: 89 Other: 3
A-7		Okra	Hand harvested 7a - High productivity: 3.75 tons/acre. 7b - Medium productivity: 1.125 tons/acre.	Inputs: 43 Machinery capital: 27 Other: 169 Inputs: 89 Machinery capital: 27 Other: 169

See footnote at end of table.

Activity Number	Activity	Description	Sources[1]
A-8	Peas	Green peas, machine harvested: yield .85 tons/acre.	Labor: 89 Other inputs: 49 Machinery: 27, 89
A-9	Lima beans	Small lima beans, machine harvested: yield .85 tons/acre.	Labor: 89 Other inputs: 69 Machinery: 27, 89
A-10	Peas & lima beans	Machine harvested: yield .85 tons/ acre. Based on 50% peas, 50% lima beans.	Labor: 89 Other inputs: 49, 69 Machinery: 27, 89 Other: 22
A-11	Soybeans	Yield 30 bushels/acre.	Labor: 27, 87 Machinery: 27, Other inputs: 27, 154
A-12	Hay	Lespedeza hay: yield 1.2 tons/ acre.	Labor: 13, 89 Other inputs: 154 Capital: 27
A-13	Manufacturing milk production	13a - New $150/cow and 20% depreciation.	3, 92, 102 Feed: 17, 92 Other inputs: 87, 92
		13b - Present $100/cow and 10% depreciation.	17, 120, 126 Value of cow: 17, 120
A-14	Market milk production	14a - Better-high capital.	Labor: 3
		14b - Better-low capital.	{27, 73, 80, 102, 3, 92
		14c - Present.	Output: 17 Feed: 3, 73, 80, 120, 167 Capital: 120 Buildings: 17
A-15	Cow-calf production	Feeder calf production. Each calf 500 lbs 15a - Better 15b - Present.	Fixed capital: 3, 27, 44, 51 Pasture: 17 Calving rate: 112 Culling rate: 17
A-16	Cattle feeding	Cattle feeding--grass and grass-lot feeding of steers and heifers--good yield.	Inputs: {29, 32, 33, 126, 3, 27
A-17	Feeder pig production	Production for sale of 14-45 lb feeder pigs per sow.	3, 5, 17, 27
A-18	Market hog feeding	Production of a 220-lb market hog.	3, 27
A-19	Pasture	50,000 acres of unused pasture land 19a - New improved 19b - Non-improved.	Labor: 17, 27, 87 Seed: 3 Fertilizer: 3 Machinery: 3, 27
CA - CONVERSION OF AGRICULTURE			
CA-1	Corn conversion	Changing from present level of inputs and outputs (present yield 42.6 bu/acre) to: mechanized production at 43.5 bu/ acre.	27, 45, 85, 107, 126, 12, 13, 17, 87
CA-2	Corn conversion	Combined mechanized-horse team production at 43.5 bu/acre.	
CA-3	Corn conversion	Horse team production at 36.8 bu/acre.	
CA-4	Corn conversion	Mechanized production plus addition of fertilizer at 72.0 bu/acre.	
CA-5	Corn conversion	Combined mechanized-horse team production plus addition of fertilizer at 72.0 bu/acre.	
CA-6	Tobacco conversion	To fully mechanized from present mix of techniques at 1750 lbs/acre.	See A-1
CA-7	Tobacco conversion	To horse from present mix of techniques at 1750 lbs/acre.	

See footnote at end of table.

Activity Number	Activity	Description	Sources[1]
*A-8	Commercial laying flock conversion	Commercialization of the laying flock activity with the increased use of feed and capital in place of unskilled labor, resulting in an increased output of eggs from 5 doz/hen to 17.5 doz/hen.	See A-6
CA-9	Manufacturing milk herd conversion	Change from $100 cow and 10% depreciation to $200 cow and 20% depreciation.	See A-13
CA-10	Pasture conversion	Conversion of 355,000 acres of pasture land from 5 acres per animal unit to 3 acres per animal unit.	See A-19
CA-11	Cow-calf conversion	Conversion from A-15b to A-15a (i.e., from "present" to "better").	See A-15
CA-12	Market milk herd conversion	High capital-using enterprise. Conversion of A-14c to A-14a (i.e., from "present" to "better"-high capital).	See A-14
CA-13	Market milk herd conversion	Lesser capital-using enterprise. Conversion of A-14c to A-14b (i.e., from "present" to "better"-low capital).	See A-14
O - OTHER ACTIVITIES (LOCAL)			
O-1	New construction	School buildings at approximate value of $12/sq ft.	Labor: 151, 153 Materials: 141
O-2	New construction	Office buildings at approximate value of $19/sq ft.	Labor & materials: 152, 153
O-3	New construction	Factory buildings at approximate value of $3.50/sq ft.	Labor seasonality: 153 Other: 3, 17
O-4	New construction	Single-family residences at approximate value of $11/sq ft.	Labor seasonality: 153 Wood: 141 Other: 149, SRI
O-5	New construction	Roads.	Labor seasonality: 153 Other: 139, 140, 141
O-6	New construction	Kilns.	121
O-7	Trade	The services of retail and wholesale trade activities representing the trade markup to consumers on factory prices.	Labor: 127 Commodities: 155 Building & paving: 81 Other capital: 41 Other: 158
O-8	Local services	Services include finance, insurance, real estate, transportation, communication, utilities, personal business, and professional services included in SIC Codes 70-89 (except 75 and 76). Estimated proportion of services purchased outside the area deducted.	Commodity inputs & ratio of gross domestic outlays to value added: 155 Capital: 41 Ratio of receipts per employee in Kentucky & the U.S.: 142 Ratio of proprietors & self employed per paid employee: 127, 131 Estimates of income per full time employee: 142 Other: 157
O-9	Automotive services & miscellaneous repair	Those activities included in SIC Codes 75, 76, 553, and 554.	Commodity inputs: 155 Other: {26 (pp. 56-62), 127, 157 (Ch. 8) "Deductions for gasoline taxes taken as 25% of sales": 26 (p. 62)

See footnote at end of table.

Activity Number	Activity	Description	Sources[1]
S-10	Eating & drinking	Eating and drinking places.	Food inputs: 99 Conversion of food inputs to model units: 78, 112, 148, 165 Other inputs than food & cost of goods sold: 26 (pp. 47-49, 54) "Taxes were eliminated": 26 Labor: 127 Building: 157 (p. 32) Other capital: 41 Other: 154
S-11	State & Local government	Based on population and school enrollment changes	128, 132, 138, 155
		11a - State and local government service for first population target, i.e., no increase blank vector	
		11b - State and local government service for second population target; only increase in school services	
		11c - State and local government service for third population target	
		11d - State and local government service for fourth population target.	
S-12	Grade A calf heifer stock	Grade A calf heifer stock.	Inputs: 102 Capital: 27, 102
S-13	Beef lot calf heifer stock	Beef lot calf heifer stock.	Inputs: 1, 27 Capital: 120
LT - LABOR TRAINING			
LT-1	Labor training	Training educated persons for skilled jobs.	14, 18, SRI

[1] Where sources are for a specific input, this input is shown. Numbers refer to items listed in List of Technical Data, p. 85.

APPENDIX B.--ACTIVITY AND COMMODITY INDEX

Activity number[1]	Commodity number	Import[1]	Export to-- Area 1[1]	Export to-- Area 2[1]	Export capacity Area 1	Export capacity Area 2
I001	C044	MI001	XIC01	XI002	E001	E002
I002	C045	MI002	XI003	XI004	E003	E004
I003	C046	MI003	XI005	XI006	E005	E006
I004	C047	MI004	XI007	XI008	E007	E008
I005	C048	MI005	XI009	XI010	E009	E010
I006	C049	MI006	XI011	XI012	E011	E012
I007	C050	MI007	XI013	XI014	E013	E014
I008	C051	MI008	---	---	---	---
	C085	---	---	---	---	---
I009	C052	MIC09	XI015	XI016	E015	E016
	C053	MI010	XI017	XI018	E017	E018
I010	C054	MI011	XI019	XI020	E019	E020
I011	K009	---	---	---	---	---
I012	C055	MI012	XI021	XI022	E021	E022
	C056	MI013	XI023	XI024	E023	E024
	C057	---	XI100	---	E124	---
I013	C058	MI014	XI025	XI026	E025	E026
	K002	MI015	XI027	XI028	E027	E028
I014	C059	---	XI083	---	E083	---
I015	C060	MI017	XI029	XI030	E029	E030
I016	C061	MI018	XI031	XI032	E031	E032
I017	C062	MI019	XI033	XI034	E033	E034
I018	C063	MI020	XI035	XI036	E035	E036
	C064	MI021	XI037	XI038	E037	E038
I019	C065	MI022	XI039	XI040	E039	E040
I020	C066	MI023	XI041	---	E041	---
I021	C067	MI024	XI042	---	E042	---
I022	C068	---	---	---	---	---
I023	C069	MI025	XI043	---	E043	---
I024	C071	---	---	---	---	---
I026	C070	MI027	XI044	---	E044	---
I027	K001	MI028	---	---	---	---

See footnote at end of table.

Activity number[1]	Commodity number	Import[1]	Export to-- Area 1[1]	Export to-- Area 2[1]	Export capacity Area 1	Export capacity Area 2
I023	C076	MI029	XI045	XI046	E045	E046
I029	C077	MI039	XI047	XI048	E047	E048
I030	C031	MI032	XI051	XI052	E051	E052
I031	C030	MI033	XI053	XI054	E053	E054
I032	C033	MI034	XI055	XI056	E055	E056
	C034	MI035	XI057	XI058	E057	E058
I033	C035	---	---	---	---	---
I034	C036	MI036	XI059	XI060	E059	E060
	C037	MI037	XI061	XI062	E061	E062
	C038	MI038	XI063	XI064	E063	E064
I035						
I036						
	C039	MI039	XI065	XI066	E065	E066
	C040	---	XI084	XI085	E084	E085
I037						
I038	C025	MI040	---	---	---	---
I039	C019	MI041	XI068	XI069	E068	E069
	C022	MI044	XI074	XI075	E074	E075
I040						
	C023	MI045	XI076	XI077	E076	E077
I041						
I042	C020	MI042	XI070	XI071	E070	E071
I043						
I044						
I045	C021	MI043	XI072	XI073	E072	E073
I046						
I047						
I048	C009	MI047	XI081	XI082	E081	E082
I049	C072	MI051	XI086	XI087	E086	E087
	C073	MI052	XI088	XI089	E088	E089
	C074	MI053	XI090	XI091	E090	E091
	C075	MI054	XI092	XI093	E092	E093
I050	C041	MI056	XI095	XI098	E095	E122
	C042	MI055	XI094	XI097	E094	E121
	C043	MI057	XI096	XI099	E096	E123

See footnote at end of table.

Activity number[1]	Commodity number	Import[1]	Export to-- Area 1[1]	Export to-- Area 2[1]	Export capacity Area 1	Export capacity Area 2
I051						
I052						
I053						
A001	C004	XA001				
	C083	---	---	---	---	---
A002	C015	MA004	XA002	---	E098	---
A003	C014	MA005	XA003	---	E099	---
A004	C013	MA006	XA004	---	E100	---
A005	C006	---	XA005	---	E101	---
A006	C007	---	XA006	---	E102	---
	C010	---				
A007	C016	MA007	XA007	---	E103	---
A008	C011	MA008	XA008	---	E104	---
A009	C012	MA009	XA009	---	E105	---
A010						
A011	C008	MA001	XA010	---	E106	---
A012	C032	MA003	---	---	---	---
A013	C018	---	XI080	---	E080	---
	C026	MI05C	XA019	XA020	E115	E116
	C027	---	XA021	XA022	E117	E118
A014	C017	---	XI067	---	E067	---
A015	C028	MA01C	XA011	XA012	E107	E108
A016	C029	MA011	XA013	XA014	E109	E110
A017	C001	MA012	XA015	XA016	E111	E112
	C002	MI049	XA023	XA024	E119	E120
A018	C003	MI048	XA017	XA018	E113	E114
A019	C084	---	---	---	---	---
	C086	---	---	---	---	---
CA001 through CA005	C005	MA002	---	---	---	---
	T002	---	---	---	---	---
CA006 & CA007	T001	---	---	---	---	---
CA008	T003	---	---	---	---	---
CA009	T005	---	---	---	---	---
CA010	T004	---	---	---	---	---
CA011	T006	---	---	---	---	---

See footnote at end of table.

Activity number[1]	Commodity number	Import[1]	Export to-- Area 1[1]	Area 2[1]	Export capacity Area 1	Area 2
CA012 & CA013	T007	---	---	---	---	---
0001	K005	---	---	---	---	---
0002	K006	---	---	---	---	---
0003	K003	---	---	---	---	---
0004	K007	---	---	---	---	---
0005	K008	---	---	---	---	---
0006	K004	---	---	---	---	---
0007	C081	---	---	---	---	---
0008	C079	---	---	---	---	---
0009	C080	---	---	---	---	---
0010	C082	---	---	---	---	---
C011	C078	---	---	---	---	---
0012	K010	MA013	---	---	---	---
0013	K011	MA014	---	---	---	---
LT001	L001	ML001	---	---	---	---
	L002	ML002	XL002	---	---	---
	L003	ML003	---	---	---	---
	L004	---	---	---	---	---
	L005	ML005	XL005			
	L006	ML006	XL006	---	---	---
	L007	ML007	XL007	---	---	---
	L008	ML008	XL008	---	---	---
	L009	ML009	XL009	---	---	---
	L010	ML010	XL010	---	---	---
	L011	---	---	---	---	---

[1] The following numbers have been dropped:

I-25	MI016	XI049	E097
	MI026	XI050	
	MI031		

END