AFRICAN RURAL EMPLOYMENT RESEARCH NETWORK

WORKING PAPER

PRELIMINARY FORMULATIONS OF POLICY MODELS
OF THE SIERRA LEONE ECONOMY EMPHASIZING
THE RURAL SECTORS

by
Hartwig de Haen, Derek Byerlee
and Dunstan S. C. Spencer

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Department of Agricultural Economics
Njala University College
Njala, Sierra Leone

Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824

THE AFRICAN RURAL EMPLOYMENT RESEARCH NETWORK

The African Rural Employment Research Network was initiated in 1971 by a group of scholars interested in comparative analysis of the development process in selected African countries with emphasis on rural employment problems. The research program has been jointly designed by scholars in African countries, at Michigan State University and at other universities in North America. Research emphasis is being directed to Sierra Leone, Nigeria and Ethiopia. In addition, individual scholars in other countries, such as Ghana, Zaire and Tanzania, are carrying out research on rural employment problems and are members of the Network.

The research program emphasizes joint and individual studies of rural employment such as the demand for labor in alternative production systems and in the rural nonfarm sector, the migration process as a link between rural and urban labor markets and the impact of macro-economic policies on labor absorption in agriculture. Attention will be directed to developing policy models to trace the consequences of alternative strategies of agricultural development on farm output, employment, income distribution and migration and to incorporating the employment objective into project, sub-sector and sectoral analysis in developing countries.

The Network maintains links with similar research networks in Latin America (ECIEL) and Asia (CAMS) and with organizations such as the FAO, ILO and the World Bank.

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Carl K. Eicher
Professor of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824

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Dunstan S. C. Spencer

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*Hartwig de Haen is Assistant Professor at the University of Bonn and Derek Byerlee and Dunstan S. C. Spencer are respectively Research Fellow and Lecturer in Agricultural Economics at Njala University College.

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I. Introduction

Research in Africa must of necessity be policy oriented. An essential aim of the rural employment research project in Sierra Leone is to evaluate alternative development strategies using the comprehensive set of micro level data generated by the field surveys. This policy evaluation is to be performed at various levels of aggregation depending on the type of policy questions to be answered. For example recommendations on the size, make and location of new rice mills or evaluation of a region specific agricultural development project will require detailed micro level analysis. On the other hand, national policy recommendations to increase rural employment and incomes must take account of intrasectoral and intersectoral dependencies, commodities, supply and demand balances and allocation of scarce national resources.

It is the aim of this paper to develop a framework for integration and aggregation of micro level data on agricultural production and processing, marketing and transport and small scale industries for national policy formulation with emphasis on employment. First the policy setting in Sierra Leone is briefly reviewed. A methodology is then developed for aggregate policy analysis that employs three separate models: (a) an aggregate micro model of small scale sectors (including agriculture), (b) a demographic migration model and (c) a macro model. Each of these models is then discussed with the macro model being described in detail.

II. The Policy Issues

The Sierra Leone government has consistently recognized that agriculture is the backbone of the national economy as evidenced from numerous policy statements in the last decade. But the growth rate in the agricultural sector has lagged far behind that of the rest of the economy. While the national economy is estimated to have grown at an annual rate of 4.3 percent in real terms, the agricultural sector is estimated to have grown at only 1.7 percent per annum [Central Statistics Office, 1972], just slightly above the official population growth rate of 1.5 percent. The growth of the national economy itself at 4.3 percent is considered unsatisfactory, it being less than the average growth rate of 5 percent achieved by developing countries as a whole.

The disparity in growth between the agricultural and nonagricultural sectors is reflected in a disparity between development in rural and urban areas, particularly between the Western Area and the other areas of the country. Overall average urban incomes are twice rural incomes [Central Statistics Office, 1968-1973]. Even within the rural areas there are regional differences in incomes reflecting differences in resource use and productivity, e.g., the disparity between the Eastern Province with cocoa, coffee and inland swamp rice and other regions.

Within the agricultural sector the failure to produce enough domestic rice for self-sufficiency has continually troubled policy makers. Up to the early fifties, Sierra Leone was self-sufficient in rice production but since then an average of 22,000 tons of rice have been imported annually.

The problem of the employment of the labor force, particularly that of urban unemployment is one that is common to all less developed countries,

and Sierra Leone is no exception. Estimates of visible une
Sierra Leone are shown in Table 1. The high rate of unemployment
town, the national capital, and Bo, the second largest city, are considered
a serious problem. Undoubtedly unemployment increased in urban areas, since from 1965 to 1971, wage employment in large scale sectors actually declined, while high rates of rural-urban migration continued.

Table 1. Unemployment in Sierra Leone

Location	Percentage of Labour Force Visibly Unemployed
Western Area	
Freetown	15.5
Other Urban	13.5
Southern Province	
Urban (1968)	10.1
Bo (1968)	15.1
Northern Province	
Urban (1968)	11.0
Eastern Province	
Urban	9.5

Source: Central Statistics Office [1968-1973].

In view of the development problems highlighted above and other social and political problems the government has recently formulated a long range development plan with the goals of [Central Planning Unit, 1973]:

(1) preserving political and economic stability as a major prerequisite for uninterrupted and continuous economic and social advancement,

(2) increasing the welfare of the broad mass of the population, and to that end,

(3) achieving more equitable distribution of wealth and income,

(4) achieving a rapid expansion of the productive capacity of the economy,

(5) creating a basis for an accelerated pace of economic and social progress,

(6) promoting economic and social development through aided self-help methods, and

(7) continuing and intensifying economic cooperation with other African countries, particularly with neighbouring countries.

Many policies and programmes to achieve these goals are contained in the development plan. Within the agricultural sector the goal is to increase the overall rate of growth from 1.7 to 5.4 percent per annum. As stated by the Minister of Finance in the last budget speech [Government of Sierra Leone, 1974]:

> The express intention of Government in adopting this strategy is to provide another source of export apart from minerals and at the same time, increase the purchasing power of the majority of the population, thus developing the internal market for industry, minimising importation of food and <u>providing more employment opportunities</u>.

Government wage policy it is said will include the following major considerations [Central Planning Unit, 1974]:

(a) reducing income differentials between the highest and lowest paid employees and maintaining minimum standards of living,

(b) maintaining industrial peace and economic and political stability,

(c) reducing migration from rural to urban areas, and

(d) limiting consumption and promoting capital formation.

The means for meeting the above goals are varied. To date government policy toward agriculture has emphasised increased rice production. This has been promoted through schemes to develop inland valley swamps such as the recent I.D.A. development project in the East to develop swamp rice through use of development loans and a seed-fertilizer package. The government has also emphasized mechanical cultivation of rice with over 55,000 acres of rice being mechanically cultivated this year. Recent evidence suggests that there should be a move away from this emphasis on swamp rice and mechanical cultivation through formulation of policies toward other rice production systems [Spencer, 1973]. In fact there are a number of alternative production systems with different input-output coefficients and different levels of technology. Policies to develop each of these systems can contribute to increased rice production but will have varying effects on rural incomes, migration and employment which have to be analysed. At present the government is also interested in developing a policy toward processing industries, particularly rice processing, i.e., the optimal number, size, type and location of processing units. Because there is a range of technologies of varying labor intensity any such policy will have important employment implications.

In addition to rice production, national policy making must consider the relative emphasis to be placed on increasing foreign exchange earnings through promotion of export crops such as cocoa and coffee and reducing imports of rice. The foreign exchange costs of reduced export earnings resulting from strong emphasis on rice production have not been fully evaluated.

Finally, various alternatives exist to increase rural employment and incomes through development of rural small scale industries. In particular the effects of government wage, trade and monetary policies need to be evaluated as they affect the relative position of small scale and large scale nonagricultural sectors of the economy.

III. Choice and Structure of the Policy Models

Choice of Appropriate Model Type

The choice of an appropriate model type is dependent upon a number of factors including the policy questions to be analysed, the type of data available and the resources available including computational facilities. In general three basic types of models have been used for planning purposes at various levels of aggregation:

(a) Consistency Models - Examples are informal commodity balances, input-output models (intra-industry, inter-industry, interregional) and macro-economic models (e.g., the type that was recently applied to employment problems by Thorbeck and Sengupta [1972]).

(b) Equilibrium models - Examples are static and comparative static programming models, e.g., the Israel model by Bruno [1966] or multiperiod models like the Mexico model by Goreux and Manne [1973].

(c) Dynamic simulation models - Examples exist from Nigeria [Manetsch, et. al., 1971] and Korea. One specific type includes dynamic programming models describing farmers' allocation decisions (e.g., de Haen and Heidhues, 1973].

These model types are generally not mutually exclusive, but each has its merits in some phase of the planning and decision making process. These phases can be identified as:

(1) Development of an information system - This would contain basic production data, input-output relationships, availability of resources and flow balances and input-output tables and is needed to test information for consistency.

(2) Explanations of cause-and-effect relationships and micro-level decision making behaviour - The analysis may be applied to farmers' resource allocation, migration decision or to the allocation of resources at the macro level. The analytic tools may be econometric models, as well as programming models conceived in a descriptive rather than prescriptive way.

(3) Long range (comparative static) policy analysis, indicating which structure of the system (allocation of physical resources, of labor and population, distribution of incomes, etc. and policy goals, e.g., employment) will result as a response to alternative policy instruments at some future point in time.

(4) Dynamic evaluation of policy effects to predict the time path of future development under alternative policies.

The amount of empirical information that is necessary to construct and to quantify the models increases as one moves from development of the information system to dynamic policy evaluation.

Currently the Rural Employment Project is mainly concerned with Phase 1, the development of an information system from primary data. This will be very time consuming and put a constraint on the time available for the analysis. Therefore, it is envisaged that the current project would not go beyond Phase 3, in which long range comparative static policy analyses will be performed. The exclusion of dynamic simulation is also necessary at this time because the availability of time series data is rather limited. Hence the emphasis will be put on consistency and equilibrium models for comparative static policy evaluation. The advantage of this approach lies in the fact that the set of linear equations on which the programming models will be based can fairly easily be developed out of the consistency analysis (input-output type) required to check the collected data. As soon as time series data become available these models should provide a basis to build dynamic models (e.g., recursive programming on the micro level).

General Structure of the Policy Models

The structure of any policy models must reflect the policy questions to be analysed. To be able to evaluate the effects of policies on rural incomes, employment and output requires the analysis of alternative technologies--many of which are industry and region specific--credit and subsidy programs, extension, etc. within the resource constraints of that

industry and region. This leads to the need for a regionally disaggregated micro-level model of the rural economy--henceforth termed the aggregate micro model. Furthermore, since agricultural processing, marketing and small-scale industries are also part of the urban economy, it is planned that this model should cover all small-scale sectors of which the rural economy is of course a subset.[1/] The primary data collection system by including urban areas provides the detailed data for constructing such an aggregate model of the small-scale sectors.

In addition, a countrywide evaluation of employment and production promotion programs requires a provision for consistency checks with the projected overall development of the economy. To list just a few, production and foreign trade of food and export crops must be consistent with rural and urban consumption. Rural-urban income differentials have to be consistent with assumptions determining migration. Migration and regional population dynamics have to be consistentwith sectoral employment projections. Rural-urban and urban-rural transfers of intermediate goods and services have to be consistent with production and input requirements. Finally, prices have to be consistent with the costs of regional production marketing, processing, transportation and government tax or subsidies.

Moreover, intersectoral linkages are not only relevant for consistency checks, but they do also have direct policy implications. A variety of policies affecting employment and rural-urban income differentials

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[1/] Small-scale here refers to firms employing six or less persons (other than family labour) and hence includes almost all the rural economy.

are implemented on the macro level directly (e.g., rice and rural input imports, rice and export crop pricing or foreign capital inflow).

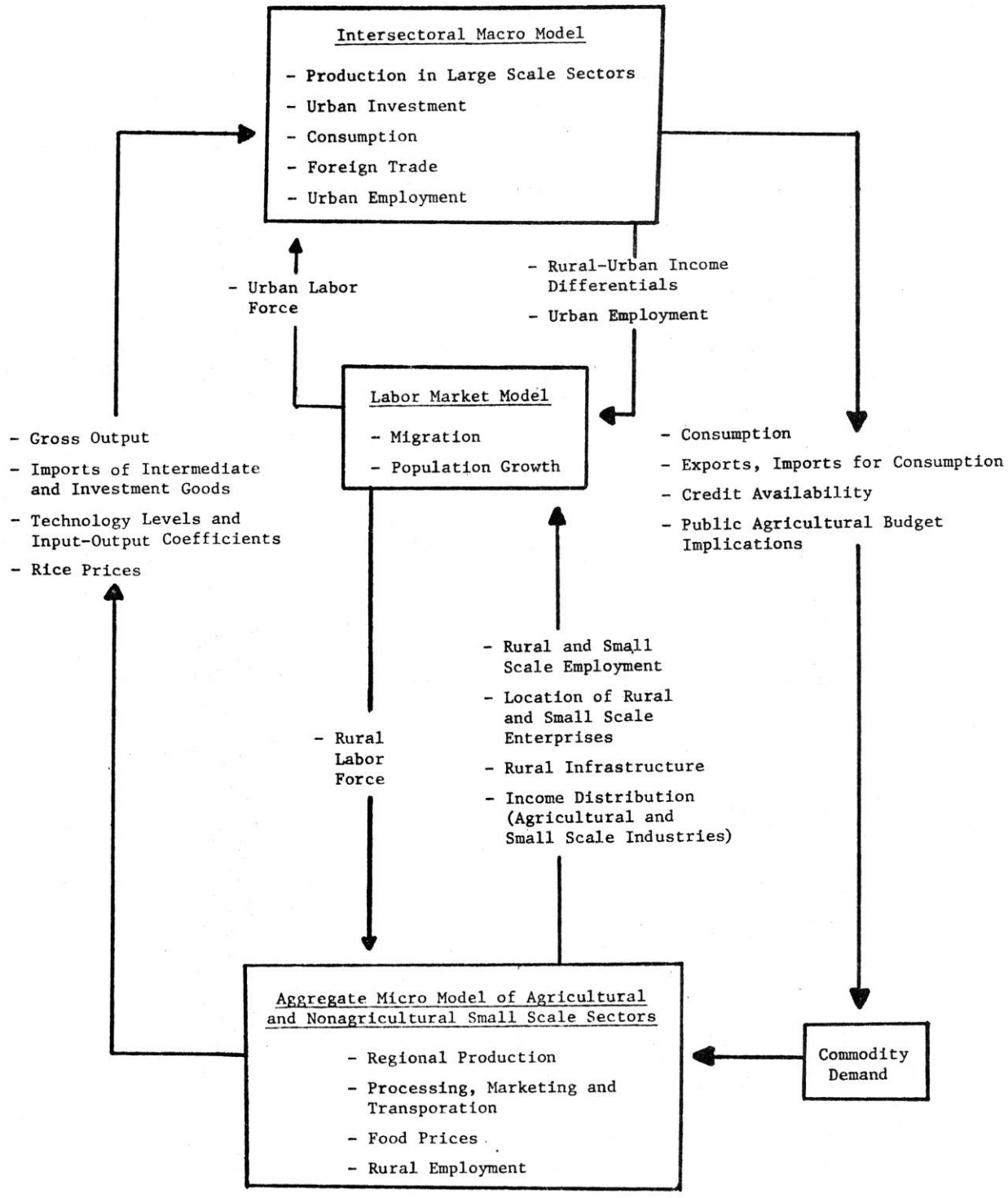
Both, the consistency and the policy implications, lead to the concept of a separate multisectoral macro model. However, the model is not exclusively based on secondary data unlike most macro-economic planning models. As far as the small scale sectors are concerned, the macro model uses the aggregated information provided by the micro level components. This information can be iteratively revised if necessary.

The macro model is designed to be flexible enough to be used for several purposes. One is the application for consistency checks by means of an intersectoral input-output table. Another area of application is the use for budgeting of various policy alternatives within the constraints relevant at the macro level. A third is the use for planning purposes as constrained maximization according to some objective function.

Finally because population growth and migration are difficult to represent realistically in the linear equations of the above models, it is proposed to construct a small model to project population and labour force and its distribution between regions.

What emerges is not one policy model, but three separate models--an aggregate micro model, a macro model and a demographic migration model--each designed to answer distinct sets of policy questions. However, the models are interdependent in the sense that exogenous variables of one model are endogenous variables of another as shown in Figure 1. Hence for overall policy evaluation, the separate models must be subject to consistency checks either through informal iteration by hand or formally through a convergence.

Figure 1. Schematic Representation of Linkage Within an Integrated Rural Employment Model of Sierra Leone



IV. The Aggregate Micro Model

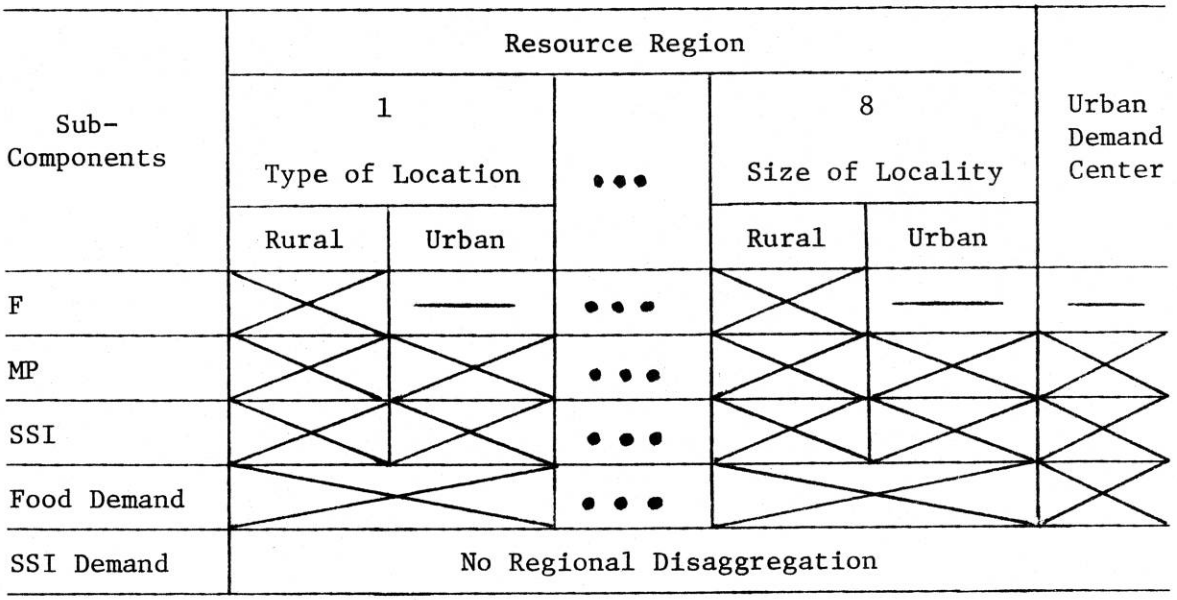
The aggregate micro model will be designed to integrate information from (a) the farm level study (F), (b) the marketing and processing study (MP), and (c) the small-scale industries studies (SSI). That is, it will be a detailed representation of the small-scale sectors of the economy. The data collection systems and analysis for each study are discussed elsewhere and only a general description of the proposed model is provided here.

Regional and Demographic Aggregation

All three studies are in one way or another disaggregated into regions or localities of different sizes to account for interregional differences in production systems, geographical concentration and specific characteristics of urban demand, transportation costs and migration. Separate analyses and evaluations of individual firm decision problems within any of the subcomponents and within any region may be performed on a representative firm basis or at the aggregate level. These firm models help to understand problems of individual firm growth or decay, firm size, investment and entrepreneural efficiency.

For the purpose of consistent countrywide analyses of production, employment and incomes under given national demand constraints and competition among firms and industries for labor and capital, the sample must be aggregated up to the relevant regional and national levels. To merge the farm level, marketing processing and small industry studies into one aggregate model, requires consistent delineation of regional and demographic subaggregates. Figure 2 contains a suitable disaggregation scheme for each

Figure 2. Aggregation Levels of Subcomponents in the Aggregate Model



F = Farm Level

MP = Marketing and Processing

SSI = Small Scale Industries

subcomponent, for use in the aggregate model. Moreover a regional breakdown of demand is proposed for the purpose of modeling transportation of domestically produced commodities to the centers of consumption (or processing) as well as of imported goods into the country. Furthermore it seems necessary to define two urban demand centers (Western Area and Kono Area) in addition to the eight resource regions. Moreover, regional centers have to be defined to compute transportation costs. Figure 3 presents a list of possible regional centers.

Linkages Between Agriculture, Processing and Small Scale Industries

The aggregate micro model will be based on an interregional linear programming format. This has several advantages. Firstly, it enables consideration of interdependencies between agricultural production, processing and small scale industries both in the factor markets (particularly the labor market) and in the product markets. Secondly if models of farm firms, rice milling enterprises and small industry firms are constructed for different firm types and regions, then they can be incorporated into the aggregate model in a "building block" fashion. Finally as discussed earlier, time constraints and objectives of the research project preclude more dynamic models.

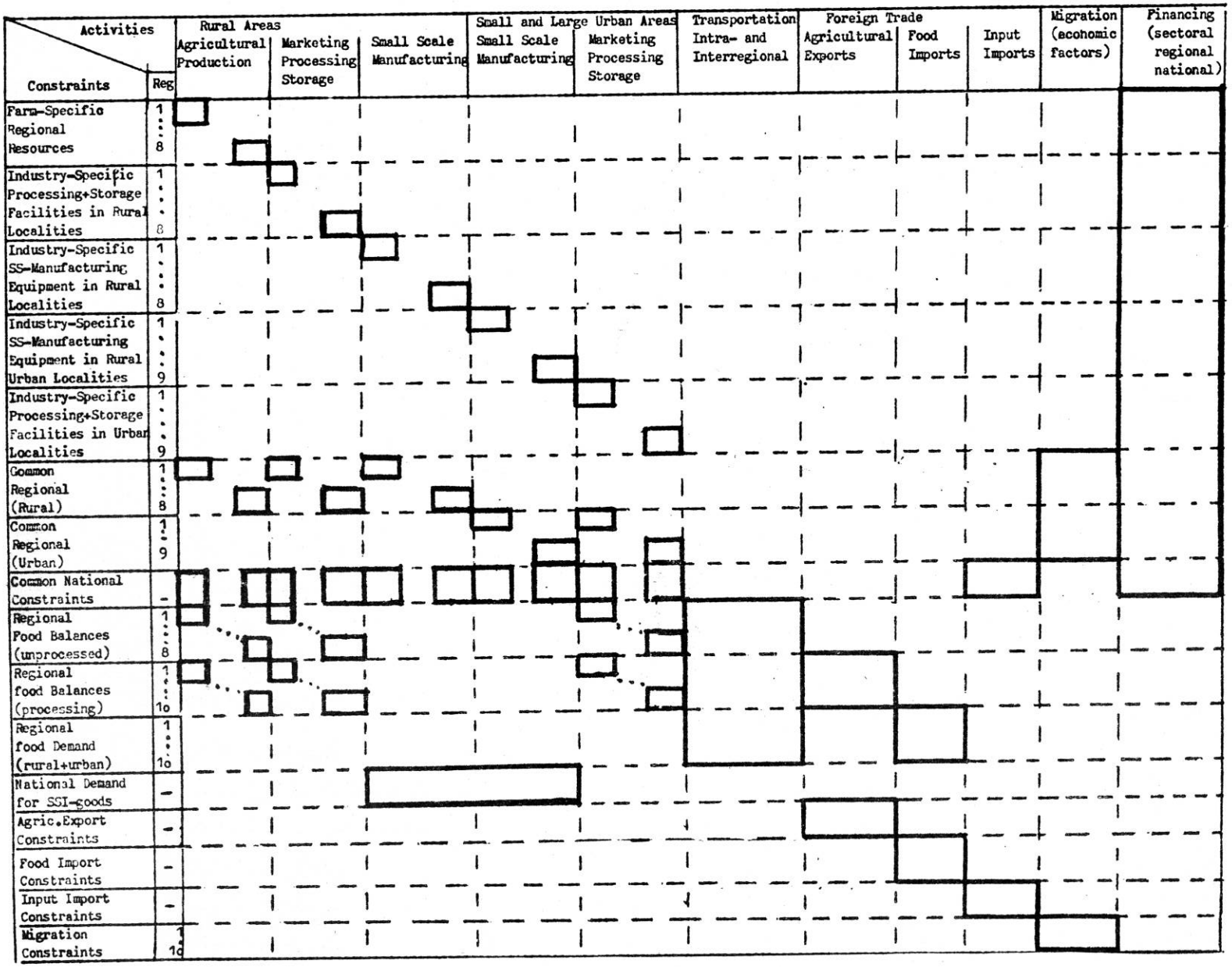
A schematic matrix representation of the linkages within the aggregate model is shown in Figure 4. The model accounts for major interactions between sectors and between regions as follows:

(a) within sectors--interregional competition to satisfy the consumer demand given foreign trade policies, interregional competition for sector specific resource constraints (e.g., fertilizer,

Figure 3. Regions and Regional Centers

Resource Region		Center	Resource Region		Center
B	No. 1	Rokupr	G	No. 6	Kenema
C	2	Bonthe	H	7	Kabala
D	3	Port Loko	I	8	Bo
E	4	Tormabum	Western Area	9	Freetown
F	5	Makeni	Kono Area	10	Sefadu

Figure 4. Linkages Between Subcomponents within the Aggregate Micro Model



agricultural budget, etc.) and

(b) between sectors-- intraregional competition for employment of the rural and urban labor force respectively; interregional competition for nationally fixed resources (e.g., government loans or subsidies for the rural sectors, foreign exchange for equipment imports, etc.).

The activity groups of the model are:

(a) sectoral and regional production,

(b) inter- and intraregional transportation,

(c) imports of food and production inputs,

(d) exports,

(e) migration and rural employment, and

(f) financing.

The sets of sectoral production activities, disaggregated by regions, and partly by sizes of locality, includes financing, investment, purchasing of inputs, hiring of labor, choice of technology, etc. The provision of alternative technologies is particularly important for analysing rural employment strategies. Using this approach, output, employment, incomes and investment by sector and region are determined endogenously and can be related to various policies. Transportation includes intraregional transfer at low or zero cost from the farm to the consumers, i.e., it also includes transfers for subsistence consumption.

The model contains the following groups of constraints:

(a) Industry specific constraints (farm land, processing mills, sewing machines, blacksmith equipment, etc.).

(b) Regional resources that are commonly used by farms, processing units, small scale manufacturers, etc., disaggregated by size

of localities. This refers mainly to the labor force disaggregated by seasons.

(c) Nationally fixed resources or policy constraints.

(d) Regional food balances for unprocessed and processed products, including export crops. These help to determine the amount of output to be processed, as well as the transportation of unprocessed commodities to processing units outside the region of production.

(e) Regional food demand constraints assuring that the net domestic supply plus imports in any region satisfies the demand (both self consumed and marketed) determined in an exogenous demand projection. Stepwise linear price demand function can be introduced here if desired, e.g., for rice.

(f) National demand for products of the small scale manufacturing industries. Here a regional breakdown of demand is not planned at this moment. However, if empirical evidence indicates regional preferences for specific items this can be accounted for in the common regional resource constraints.

(g) Foreign trade constraints. They include both balances and limits to foreign exchange, as well as policy determined trade limits to specific products. The latter refers particularly to rice import policies of the Rice Corporation.

(h) Migration constraints. Although migration will be analysed within a separate model, it may be useful to include a limited migration subcomponent in the aggregate model to determine levels and directions of migration flows as affected by economic factors.

V. The Demographic-Migration Model

In most policy models population and migration are treated exogenously. Although migration activities are sometimes included in linear programming type models, problems arise in realistic representation of the migration decision because of the linear assumption. The purpose of the demographic-migration model is then to provide a more detailed analysis of population growth and population distribution. These variables are used in both the aggregate micro model and the macro model to project commodity demands and regional labour supply.

Projection of total population and its composition will be based on standard demographic models (e.g., the Michigan State University simulation DEMOG program) using estimates of age-sex fertility and mortality rates from the migration surveys. If these surveys show statistically significant differences in demographic parameters between regions, the population can be disaggregated for projection. At this stage it appears that at least a rural-urban delineation will be necessary. It is also tentatively planned that fertility and mortality be related to socio-economic variables thus making total population endogenous in the model.

Population and labour force distribution will be determined through modeling of both interregional rural-rural migration and rural-urban migration as described in Tommy and Byerlee [1974]. Basically this involves econometric estimation of the equation:

$$M_{ijk} = f\ (Y_{ik},\ Y_{jk},\ E_i,\ E_j,\ R_i,\ R_j)$$

where

M_{ijk} is the rate of migration of the k^{th} age-sex cohort from region i, to region j (where regions are defined with respect to both geographical location and rural-urban location),

Y_{ik}, Y_{jk}	are measures of income in the i^{th} and j^{th} region respectively,
E_i, E_j	are rates of employment expansion in region i and j, and
R	are exogenously fixed variables such as distance.

These migration equations determine population distribution and hence labor supply to each rural and urban area. In turn the income and employment variables of the equation are determined in the aggregate micro model and the macro model so that iterative procedures may be necessary to ensure consistency between these components.

VI. The Macro Model

Sectoral Disaggregation

The sectors of the macro model are defined on the basis of both rural-urban location and firm size. Three geographical locations are distinguished: (1) rural areas consisting of localities of less than 2,000 persons, (2) small urban areas with populations between 2,000 and 20,000 and (3) large urban areas with populations of over 20,000.[1/]

Industries are further disaggregated by small scale and large scale industries, with large scale industries defined as those consisting of firms employing six or more persons excluding family members.[2/] The small

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[1/] The official Sierra Leone definition of an urban center includes both small urban and large urban centers while the standard U.N. definition would define only large urban centers as urban.

[2/] For some industries the possibility of introducing an intermediate category consisting of firms with 6 to 50 employees is being explored.

scale sectors of course are an aggregation of sectors considered in more detail in the aggregate micro model.

Given these definitions, 15 sectors are deliniated in Table 2 and schematically represented in Figure 5. In general this sectoral disaggregation is necessary if employment, incomes and migration are to be analysed since the size and technology of the firm and the rural-urban location are important. The breakdown also corresponds to the data collection system and the structure of the aggregate micro model.

Structure of the Macro Model

The model is schematically represented in Figure 6 and the equations given in the Appendix. Basically the macro model consists of a simultaneous set of linear equations, some of which have the form of inequalities depending on the actual purpose of model application (consistency, budgeting and optimisation). The major components of this model are:

(a) an input-output table (commodity balances),

(b) a set of savings and consumption functions for three population groups,

(c) a set of investment equations,

(d) import and export balances,

(e) foreign exchange constraints,

(f) urban employment and unemployment equations, and

(g) national and sectoral accounting equations.

Table 2. Sectoral Disaggregation

	Sector Number	Sector Name	Location
Small Scale Sectors	1	Rice	Rural
	2	Other Food Crops	Rural
	3	Export Crops	Rural
	4	Agricultural Processing - R	Rural
	5	Agricultural Processing - U1	Small Urban
	6	Agricultural Processing - U2	Large Urban
	7	Small Scale Manufacturing - R	Rural
	8	Small Scale Manufacturing - U1	Small Urban
	9	Small Scale Manufacturing - U2	Large Urban
	10	Agricultural Trade and Transport	Not Location Specific
	11	Small Scale Nonagricultural Trade	Not Location Specific
Large Scale Sectors	12	Construction	Small and Large Urban
	13	Mining	Large Urban
	14	Large Scale Manufacturing	Large Urban
	15	Large Scale Trade and Services Including Utilities	Large Urban

Figure 5. Stratification of Sectors and Geographical Areas

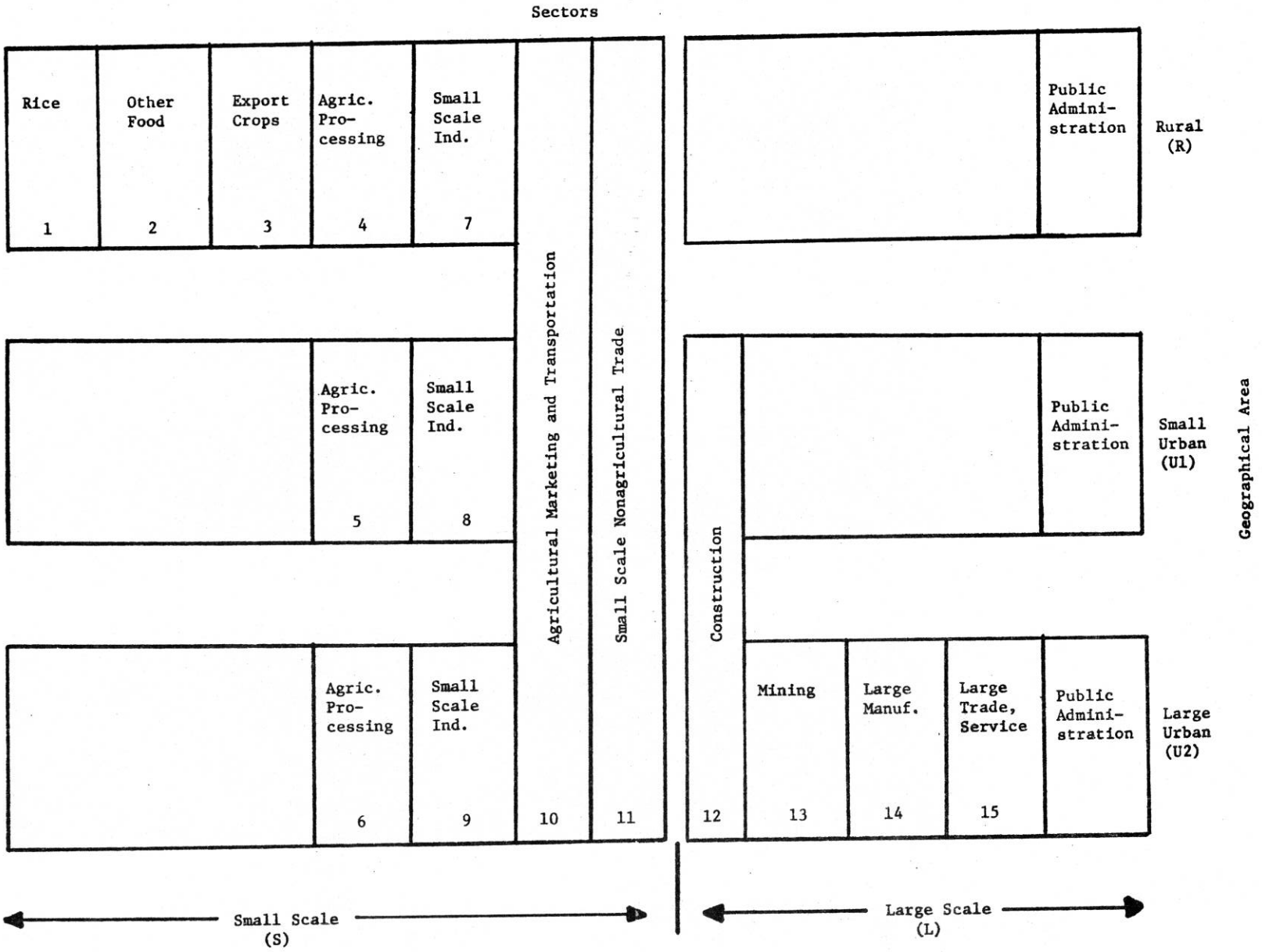

Figure 6. Schematic Matrix Representation of the Macro Model

Activities (Endogenous) / Constraints	Production			Consumption of Domestic Products			Investment		Exports	Imports	Urban Unemployment	Savings	Accounting
	Rural Small Scale	Urban Small Scale	Large Scale Nonagr. Urban	Rural	Medium	Urban	Rural and Small Scale	Large Scale Nonagr. Urban					
Commodity Balances	X	X	X	X	X	X	X	X	X				X
Consumption Functions				X	X	X				X		X	X
Capital Goods Constraints			X				X	X		X			
Imports Intermediate Investment Consumption	X	X	X				X	X		X X X			X
Exports									X				X
Foreign Exchange									X	X			
Urban and Public Employment		X	X								X		X
Predetermined Levels of Rural Sectors	X	X					X						
Savings												X	X
National Accounting													X

By introducing three population groups with specific savings behavior and consumption patterns the model can determine the level of food self-sufficiency resulting from population growth, income changes and migration. Moreover the model can explain urban unemployment rates as a function of urban labour force projections and the computed employment in urban sectors. Exogenous variations of factor intensities (i.e., capital-labor ratios) within the urban sectors will also be analysed with respect to their effect on urban unemployment. Finally, public employment will be considered to be exogenously determined by the size of the public budget and minimum wage policies.

The model may be solved through standard input-output procedures, budgeting or optimisation. In the case of an input-output consistency solution, sectoral output is assumed exogenous and computed endogenously for given final demand. With comparative static optimisation, large scale output and hence urban employment and investment are endogenous. Of course, output and employment in the small scale sectors are exogenous since these are treated in the aggregate micro model.

Model Applications--Macro Economic Implications of Employment Policies

As discussed earlier, the model is designed to evaluate the macro level implications of micro-level employment and income policies. Given (a) production in agriculture, processing and small scale industry sectors, (b) the resulting input-output coefficients and (c) population growth and migration decisions, the model will show the impact on urban production, foreign trade and urban income and employment, as well as total output and employment in the country. This however will require a series of consistency

checks. Clearly, the structure of the macro model itself will always provide internal consistency within the macro model. However, the building block approach, i.e., the nonsimultaneous computation of the three subaggregates, may lead to several intercomponent inconsistencies shown in Table 3.

The purpose of the intercomponent consistency checks at the macro level will be to conduct repeated model calculations until the inconsistencies lie within a certain range. At this time it is not planned to develop a formal iteration algorithm that would lead to automatic convergence. A nonformal adjustment of model parameters "by hand" appears more appropriate and sufficient.

Once the macro model is reasonably consistent with the other subaggregates, it may also be used for independent comparative static computations. These include input-output projections, constrained optimization (e.g., finding the maximum value of total final consumption), parametric variation of policy variables. Used in an optimization mode, the model solution will contain a primal and a dual, i.e., both the allocation and a pricing problem will be solved. The latter may help to identify bottlenecks for further development and how they are affected by the policies under consideration.

Model Parameters and Need for Further Data Collection

Data collection and quantitative information is necessary for the exogenous variables and for the model parameters that are not predetermined in other components. The model parameters are defined as follows:

Table 3. Variables with Potential Intercomponent Inconsistency

	Variable of Macro Model	Variable of Aggregate Micro Model	Variable of Demographic/ Migration Model
1.	Total consumption of commodities from small scale sectors	Production and imports of small scale commodities	Labor supply to small scale sectors
2.	Input-output coefficients	Production technologies of small scale sectors	
3.	Rice demand	Rice prices	
4.	Public budget	Revenues and expenditures in agriculture	
5.	Rural-urban incomes differential and employment	Interregional income differential	Rural-urban and interregional migration

a_{ij}	interindustry input-output coefficients for goods and services transferred from "i" to "j"
b_{ij}	capital required from sector "i" per unit of gross investment in sector "j"
k_i	incremental capital output ratio in sector "i"
r_i	replacement rate in sector "i"
s	average propensity to save, specific for population groups R, U1 and U2
e_i	expenditure elasticity of demand for commodity group "i", produced domestically; specific for population group R, U1 and U2
n_i	own price elasticity for rice; specific for population group R, U1 and U2
m_j^x	import requirements of intermediate goods per unit of output of sector "j"
m_j^v	import requirements of investment goods per unit of investment in sector "j"
u_i	elasticity of import of consumer good from sector "i" with respect to expenditure; specific for population group R, U1 and U2
w_1, w_2	parameters of regression function relating public employment to the public budget and the wage rates
g	regional breakdown of public administration, defense and services (R, U1 and U2)
r	regional breakdown of overlapping sectors 10, 11 and 12 into areas R, U1 and U2
l_j	labor input per unit of output in sector "j".

Table 4 indicates the data sources available or necessary to quantify parameters and variables not predetermined in the other components. In general most data are being collected from primary sources. However, for the large scale sectors in urban areas, secondary sources are utilized. In special cases such as for large scale input-output coefficients special

Table 4. Sources for Data of the Macro Model

	Source	
	Small Scale Sectors	Large Scale Sectors
a, b, k, m^x m^v, 1	Predetermined in aggregate micro model, original data from primary survey (F, MP, SSI)	Secondary sources, in some cases complemented by one contact questionnaire
	Rural Localities	Urban Localities
s, d, n, u, r	Estimates from primary data (household survey)	Estimates from secondary sources, Central Office of Statistics: household expenditure survey
g, r	Both primary and secondary	
	National Level	
w_1, w_2, A PWS, $\overline{W}$	National accounts and official statistics	

surveys may have to be undertaken. Finally the level of the small scale sectors' output as well as the aggregated input-output coefficients will be taken from the optimal solution obtained for the micro model. Thus, the technology represented by the Leontieff production functions of the macro model is not fixed but depends on substitution processes taking place within the small scale sectors.

VII. Plans for Constructing Models

All the model building activities will proceed in stages. First the raw data will be sorted to identify errors in reporting, coding, etc. Then various consistency checks of data will be performed to ensure commodity balances, etc. The model can then be constructed and consistency checks again performed to ensure that the present structure of the economy does not violate resources and other constraints of the model. Finally policy analysis can then be performed using either consistency, budgeting or optimization techniques.

Because three separate models have been identified, each can be constructed separately and consistency obtained at a later date. For example the macro model can be constructed initially using secondary data for agriculture and other small scale sectors. Later estimates of parameters can be obtained from the aggregate micro model. The aggregate micro model, the largest and most complex of the three can be constructed on a building block approach beginning with models specific to a given sector (e.g., farm, processing, small scale industries) and a given region. These can then be merged in stages with appropriate steps at each stage to ensure consistency.

References

Bruno, M., "A Programming Model for Israel," in The Theory and Design of Economic Development, edited by I. Adelman and E. Thorbecke, Baltimore, 1966, Chapter 6.

de Haen, H. and T. Heidhues, "Recursive Programming Models to Simulate Agricultural Development--Applications in West Germany," Institute for Agricultural Economics, Working Paper No. 18, Goe Hingen, 1973.

Goreux, L. M. and A. S. Manne (eds.), Multi-Level Planning: Case Studies in Mexico, Amsterdam, 1973.

Manetsch, et. al., A Generalized Simulation Approach for Agricultural Sector Analysis with Special Reference to Nigeria, East Lansing, 1971.

Sierra Leone, Government of, "National Accounts of Sierra Leone, 1964/65-1970/71."

_____, "Household Statistical Survey of Sierra Leone," Central Statistics Office, 1968, 1973.

_____, "Budget Speech by Minister of Finance, Honorable C. A. Kamara-Taylor," Government Printer, Freetown, 1974.

_____, "Draft Ten Year Development Plan," Central Planning Unit, Ministry of Development and Economic Planning, 1974.

Thorbecke, E. and J. Sengupta, "A Consistency Framework for Employment, Output and Income Distribution Projections Applied to Colombia," Development Research Center, IBRD, Washington, D.C., 1972.

Appendix

Equations of the Macro Model

1. Exogenous Variables[1/]

$\bar{A}$	(P)	Total public expenditure on goods and services
G_i	(P)	Public consumption of domestically produced goods or services from sector i (i=1,...,15)
$\bar{X}_i$	(*)	Gross output from small scale sectors i (i=1,...,10)
$\bar{B}_i^S$	(*)	Investment goods from urban sector "i" required by the small scale sectors (i=11,...15)
N^R	(*)	Rural population
N^{U1}	(*)	Small urban population
N^{U2}	(*)	Large urban population
L^{U1}	(*)	Small urban labor force
L^{U2}	(*)	Large urban labor force
$\bar{M}_v^S$	(*)	Imports of investment goods for small scale sectors
$\bar{M}_x^S$	(*)	Imports of intermediate goods for small scale sectors
$\bar{I}_i$	(*)	Gross investment in small scale sector "i"
F	(P)	Foreign exchange available from sources other than exports

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[1/] "P" represents policy determined variables and "*" represents variables predetermined in the micro model.

X_i^F		Upper or lower flexibility bounds on the level of output of large scale sector "i" (i=11,...,15)
P_1	(*)	Consumer price of rice

2. Endogenous Variables

X_i	Gross output of large scale urban sector "i" (i=11,...,15)
I_i	Gross investment of large scale urban sector "i" (i=11,...,15)
B_i	Investment goods produced by large scale sector "i" (i=11,...,15)
C_i^R, C_i^{U1}, C_i^{U2}	Final goods from sector "i", produced domestically and consumed by population group R, U1 or U2 respectively (for rice: total consumption "C_1")
M_x^L	Imports of intermediate goods used in the large scale sectors (noncompetitive)
M_v^L	Imports of investment goods used for investment in large scale sectors (noncompetitive)
M_c^R, M_c^{U1}, M_c^{U2}	Noncompetitive imports of goods from sector "i", consumed by population group R, U1 or U2 respectively
M_1^R, M_1^{U1}, M_1^{U2}	Competitive imports of rice, consumed by population group R, U1 or U2

3. Commodity Balances[1/]

$$\sum_{j=1}^{15} a_{ij} X_j + C_i^R + C_i^{U1} + C_i^{U2} + \sum_{i=1}^{15} b_{ij} I_j + E_i + G_i - M_i < X_i$$

$i=1,\ldots,15$
($m_1 = o$ if $i \neq 1$) Eq. 1,...,15

[1/] $M_1 = M_1^R + M_1^{U1} + M_1^{U2}$ and designates competitive imports of rice. All other imports are assumed noncompetitive.

4. Investment

(a) Large scale sectors:

Assuming (for simplification) a linear capacity increase $(X_i - X_i^o)/T$ between the base year 0 and the projection year T and a marginal capital-output ratio k_i, the average necessary net investment I_i^N is

$$I_i^N = (X_i - X_i^o)\, k_i/T \ .$$

Assuming further that replacement R_i is linearly related to gross output (due to constant rate of capacity utilization)

$$R_i = r_i\, X_i .$$

Gross investment I_i is given by $I_i = R_i + I_i^N$,

yielding the set of equations for large scale sectors

$$X_i\,(k_i + r_i) - T\, I_i = k_i\, X_i^o \qquad \text{Eq. } 16,\ldots,19$$

$$i = 12,\ldots,15$$

(b) Small scale sectors (Predetermined)

$$I_i = \bar{I}_i \qquad i = 1,\ldots 11 \qquad \text{Eq. } 20,\ldots,30$$

5. Small Scale Sector Production Constraints (Predetermined)

$$X_i = \bar{X}_i \qquad i = 1,\ldots,11 \qquad \text{Eq. } 31,\ldots,41$$

6. Flexibility Bounds for Selected Large Scale Sectors

Possibly necessary to reflect constraints on skills, management, speed of expansion, etc. that are not explicitly included in the model:

$$X_i < X_i^F \qquad i = 12,\ldots,15 \qquad \text{Eq. } 42,\ldots,45$$

7. Savings (Public and Private)

$$C^R = (1 - s^R) \quad GDP^R \qquad \text{Eq. 46}$$

$$C^{U1} = (1 - s^{U1}) \quad GDP^{U1} \qquad \text{Eq. 47}$$

$$C^{U2} = (1 - s^{U2}) \quad GDP^{U2} \qquad \text{Eq. 48}$$

8. Sectoral Consumption Functions

Except for rice prices which are predetermined in the aggregate micro model, price effects are neglected. Then assuming a piece wise linear approximation of the consumption function in the neighbourhood of the initial expenditure shares

$$C_i^o/C^o,$$

consumption C_i is determined by conventional income elasticity procedures:

$$\frac{C_i}{N} = \frac{C_i^o}{N} \left(1 + e_i \frac{C - C^o}{C^o}\right) \qquad i = 1,\ldots,15$$

where e_i is the income elasticity of demand and total consumption C has been previously determined in savings equations 46, 47 and 48. Consumption of each commodity is however computed independently for each population group using separate series of income elasticities:

$$e_i^R, e_i^{U1}, e_i^{U2} \quad \text{to give} \quad C_i^R, C_i^{U1}, C_i^{U2} .$$

Eq. 49,...,93[1/]

9. Imports

(a) Imports of intermediate goods, large scale sectors:

$$\sum_{j=12}^{15} m_j^x X_j = M_x^L . \qquad \text{Eq. 94}$$

[1/] Note C, consumption of rice, is total consumption including competitive imports.

(b) Imports of investment goods, large scale sectors:

$$\sum_{j=12}^{15} m_j^v I_j = M_v^L \qquad \text{Eq. 95}$$

(c) Imports of noncompetitive consumer goods:

Imports by population group for consumption, M_c^R, M_c^{U1}, M_c^{U2} are determined in an analogous manner to domestic consumption by the following general equation:

$$\frac{M_c}{N} = \sum_{i=2}^{15} M_i^o \left(1 + U_i \frac{C - C^o}{C^o}\right) \qquad \text{Eq. 96, 97, 98}$$

Overall consumption good balances are then given by:

$$M_c^R - C^R + \sum_{j=1}^{15} C_j^R = 0 \qquad \text{Eq. 99}$$

$$M_c^{U1} - C^{U1} + \sum_{j=1}^{15} C_j^{U1} = 0 \qquad \text{Eq. 100}$$

$$M_c^{U2} - C^{U2} + \sum_{j=1}^{15} C_j^{U2} = 0 \qquad \text{Eq. 101}$$

10. Foreign Exchange Requirements

$$M_1 + M_c^T + M_x^T + M_v^T - E = F \qquad \text{Eq. 102}$$

11. Urban Employment and Unemployment

(a) Employment in public administration:

Assuming that national employment in public administration, L_G, is a function of public wages and salaries account PWS and the governmental minimum wage rate, W, we get:

$$L_G = w_1 \, PWS + w_2 \, W \qquad \text{Eq. 103}$$

From this we take certain (policy determined) proportions "g" to indicate the geographical distribution of public administration employment by the three geographical areas:

$$L_G^R = g^R L_G \qquad \text{Eq. 104}$$

$$L_G^{U1} = g^U L_G \qquad \text{Eq. 105}$$

$$L_{G_*}^{U2} = L_G - L_G^R - L_G^{U1} \qquad \text{Eq. 106}$$

(b) Total urban employment:

Small urban:

$$l_5 X_5 + l_8 X_8 + \sum_{1=10}^{12} r_i^{U1} l_i X_i + L_G^{U1} + U^{U1} = L^{U1} \qquad \text{Eq. 107}$$

Large urban:

$$l_6 X_6 + l_9 X_9 + \sum_{1=10}^{12} r_i^{U2} l_i X_i + L_G^{U2} + U^{U2} = L^{U2} \qquad \text{Eq. 108}$$

where r_i is the breakdown of overlapping sectors among geographical areas. U is unemployment.

12. National and Sectoral Accounting

(a) Current public expenditure on goods and services and its composition:

Total expenditure on goods and services is exogenously determined by:

$$A = \overline{A} \qquad \text{Eq. 109}$$

(b) Total public administration, defense and services (education, health) is then:

$$PWS = A - \sum_{i=1}^{15} G_i \qquad \text{Eq. 110}$$

(c) Investment:

Rural: $$I^R = \sum_{j=1}^{7} I_j + r^R_{10} I_{10} + r^R_{11} I_{11} \qquad \text{Eq. 111}$$

Small urban: $$I^{U1} = I_5 + I_8 + \sum_{j=10}^{12} r^{U1}_j I_j \qquad \text{Eq. 112}$$

Urban: $$I^{U2} = I_6 + I_9 + \sum_{j=10}^{12} r^{U2}_j I_j + \sum_{j=13}^{15} I_j \qquad \text{Eq. 113}$$

(d) Exports:

Exports of agricultural goods are predetermined in the aggregate micro model and exports of minerals exogenously set.

(e) Imports:

Consumption: $$M^T_c = M^R_c + M^{U1}_c + M^{U2}_c \qquad \text{Eq. 114}$$

Inputs: $$M^T_x = \bar{M}^S_x + \bar{M}^L_x \qquad \text{Eq. 115}$$

Capital goods: $$M^T_v = \bar{M}^S_v + \bar{M}^L_v \qquad \text{Eq. 116}$$

(f) GDP:

Rural: $$GDP^R = \sum_{j \in R} X_j - \sum_{i \in R} \sum_{j=1}^{15} a_{ij} X_j + g^R PWS \qquad \text{Eq. 117}$$

$$R = (1,\ldots,7, 10, 11)$$

Small urban: $$GDP^{U1} = \sum_{j \in U1} X_j - \sum_{i \in U1} \sum_{j=1}^{15} a_{ij} X_j + g^{U1} PWS \qquad \text{Eq. 118}$$

$$U1 = (5, 8, 10, 11, 12)$$

$$\text{Urban:} \quad GDP^{U2} = \sum_{j \in U2} X_j - \sum_{i \in U2} \sum_{j=1}^{15} a_{ij} X_j + g^{U2} \, PWS \qquad \text{Eq. 119}$$

$$U2 = (6, 9, 10, \ldots, 15)$$

13. Objective Function (Example)

$$\text{Maximize:} \quad C^R + C^{U1} + C^{U2} + M_c^R + M_c^{U1} + M_c^{U2} + M_1$$

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Working Papers, African Rural Employment Research Network, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan 48824.