Agricultural Sector Planning Models: 
A Selected Summary and Critique

World Bank Staff Working Paper No. 297

October 1978

The views and interpretations in this document are those of the authors and should not be attributed to the World Bank, to its affiliated organizations, or to any individual acting in their behalf.

Prepared by: A.C. Egbert
Agriculture and Rural Development Department

Copyright © 1978
The World Bank
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.
The views and interpretations in this document are those of the authors and should not be attributed to the World Bank, to its affiliated organizations, or to any individual acting in their behalf.

WORLD BANK

Staff Working Paper No. 297

October 1978

AGRICULTURAL SECTOR PLANNING MODELS:
A SELECTED SUMMARY AND CRITIQUE

This report provides a description and evaluation of seven selected Agricultural Sector Planning Models. The purpose is: (i) to provide guidance to those considering their use either in experimental or actual planning, and (ii) to present for a wider audience a brief account and evaluation of a representative set of such models and their applications in developing countries.

The report includes, in its earlier sections, a summary of some special concepts which are considered useful in agricultural sector planning, and planning in general.

The general conclusion of this review is that such models need more testing. How well they can perform in actual planning is not known. Until it is known it would seem prudent to apply these models cautiously, and perhaps in conjunction with less complex and expensive tools.

Prepared by: A.C. Egbert
Agriculture and Rural Development Department

Copyright © 1978
The World Bank
1818 H Street, N.W.
Washington, D.C. 20433 U.S.A.
# Table of Contents

SUMMARY AND CONCLUSIONS ......................................................... 1-iv  
I. INTRODUCTION ................................................................. 1  
  Terminology and Alternative Models ........................................ 2  
  Relevant Dimensional Concepts in Sector Analysis ....................... 5  
  Critique Procedure ................................................................ 8  
  Studies to be Evaluated .......................................................... 10  

II. THE PERU AND GUATEMALA STUDIES ........................................ 10  
  Objectives .............................................................................. 10  
  Methodology ........................................................................... 11  
  Results ................................................................................... 12  
  Evaluation .............................................................................. 13  

III. PLANNING AND DEVELOPMENT MODELS FOR THE AGRICULTURAL  
    SECTORS OF PORTUGAL AND BRAZIL ....................................... 14  
  Objectives .............................................................................. 15  
  Methodology ........................................................................... 16  
  Empirical Structure of the Brazilian Model ................................ 17  
  Empirical Structure of the Portuguese Model ............................ 18  
  Results ................................................................................... 19  
  Evaluation .............................................................................. 23  

IV. KOREAN AGRICULTURAL SECTOR STUDY .................................... 24  
  Objectives .............................................................................. 24  
  Methodology ........................................................................... 25  
  Results ................................................................................... 29  
  Evaluation .............................................................................. 30  

V. MULTI-LEVEL PLANNING: CASE STUDIES IN MEXICO ................... 32  
  Objectives .............................................................................. 33  
  Methodology ........................................................................... 33  
  Results ................................................................................... 35  
  Evaluation .............................................................................. 40
<table>
<thead>
<tr>
<th>VI. MULTI-LEVEL PROGRAMMING STUDIES IN THE IVORY COAST</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>44</td>
</tr>
<tr>
<td>Methodology</td>
<td>45</td>
</tr>
<tr>
<td>The Central Model</td>
<td>45</td>
</tr>
<tr>
<td>The Agricultural Sector Model</td>
<td>46</td>
</tr>
<tr>
<td>The Urban Sector Model</td>
<td>47</td>
</tr>
<tr>
<td>The Educational Model</td>
<td>47</td>
</tr>
<tr>
<td>General Results</td>
<td>48</td>
</tr>
<tr>
<td>Return to Labor</td>
<td>49</td>
</tr>
<tr>
<td>Foreign Exchange and Savings</td>
<td>50</td>
</tr>
<tr>
<td>Policy Experiments</td>
<td>52</td>
</tr>
<tr>
<td>Evaluation</td>
<td>55</td>
</tr>
<tr>
<td>Bibliography</td>
<td>57</td>
</tr>
</tbody>
</table>
SUMMARY AND CONCLUSIONS

There have been a number of ambitious projects to develop and apply agricultural sector models in developing countries. This report attempts to summarize and evaluate a cross-section of those studies. Those reviewed here are agricultural sector studies (and in some countries total economy) in Peru, Guatemala, Korea, Brazil, Portugal, Mexico and the Ivory Coast.

The objective of this report was not to review all sector studies that have been undertaken by or for developing countries, but to review a group that represented a spectrum of relatively unique methodologies. However, in two instances, the studies reviewed included application of similar methodology to two countries.

A number of other sector studies are underway that probably should have been included here. They are for Thailand, Malaysia, Tunisia, Central America, N.E. Brazil, Zambia. However, final reports were not available at the time of this writing. Moreover, some are partial sector studies. A secondary objective was to review only studies that included most if not all of the products and resources of the agricultural sector. Nonetheless, these studies should and probably will be the subject of subsequent reviews and critiques.

Professor Erik Thorbecke did a review of some of the same studies several years ago (17). However, in this report more attention is given to the actual results obtained and a different perspective is used for the critique.
In the following chapters, each of these models is summarized in as much detail as seemed warranted, including objectives of the studies, the methodology employed and some evaluation of their general usefulness. The reader may find for each of these categories certain deficiencies in this summary and critique which usually can be laid to limitations of the writer. The first chapter attempts to develop a frame of reference for evaluating models and analyses of such nature.

Objectives of designing and applying sector models may be different. In the first instance, the objective may be to explain how the sector "works": the important variables or factors, their functional relationship within and between periods and their parameters. The ultimate objective is, however, to determine how the sector can be "managed" to obtain certain development goals. Therefore, the final test of a model's adequacy is its record for achieving development goals. Unfortunately, the reports reviewed here do not present the "track records" of the models. This may come in some instances in the future. Hence, it was not possible to evaluate any of the models in the ultimate sense.

A summary of the more important characteristics of each of the models is presented in Table 1. The first two studies--Peru-Guatemala and Korea--use simulation methods (realizing, of course, the broadness of this term). On the other hand, studies in the four other countries--Brazil, Portugal, Mexico and the Ivory Coast--employ constrained optimization or Linear Programming methods. The objective function is the same for Brazil, Portugal and Mexico--maximization of producers and consumers' surplus which is equivalent to competitive equilibrium. The objective function of the Agricultural Sector Model in the Ivory Coast is maximization of returns to rural resources or rural income.
<table>
<thead>
<tr>
<th>Item</th>
<th>Peru and Guatemala</th>
<th>Korea</th>
<th>Brazil</th>
<th>Portugal</th>
<th>Mexico</th>
<th>Ivory Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective (function)</td>
<td>Simulation of labor requirements under alternative growth rates and technology</td>
<td>Simulation of agricultural growth for output, employment and income under alternative programs and policies</td>
<td>Competitive equilibrium (maximum producer's and consumer's surplus)</td>
<td>Competitive equilibrium (maximum producer's and consumer's surplus)</td>
<td>Competitive equilibrium (maximum producer's and consumer's surplus)</td>
<td>Maximization of returns to rural resources</td>
</tr>
<tr>
<td>Commodities</td>
<td>Peru: 13 crops Guatemala: 11 crops</td>
<td>12 crops</td>
<td>21 crops</td>
<td>15 crops</td>
<td>33 short cycle crops</td>
<td>11 crops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 livestock products fish</td>
<td>9 livestock products</td>
<td>8 livestock products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource constraints</td>
<td>Labor</td>
<td>Not explicit</td>
<td>Land - 3 classes</td>
<td>Labor - 6 classes</td>
<td>Land - monthly, family and hired, skilled and unskilled</td>
<td>Land</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Labor</td>
<td>Labor</td>
<td>Labor - monthly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Animal power</td>
<td>Quarterly power</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Current inputs</td>
<td>Livestock product processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Livestock inventory</td>
<td>Meat storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transportation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special delineation</td>
<td>None</td>
<td>3 regions</td>
<td>13 regions for production and consumption</td>
<td>11 regions for production and consumption</td>
<td>20 regions for production only</td>
<td>2 regions</td>
</tr>
<tr>
<td>Linkages to other sectors and total economy</td>
<td>Seven-sector input-output system and demographic model</td>
<td>National input-output system and demographic model</td>
<td>Agricultural product processing and distribution, part retail level and part farm level, and transportation and port facilities</td>
<td>Agricultural product processing and distribution through the retail level</td>
<td>Downward linkages with central model (DINAMICO) for interest rate, foreign exchange rate, income growth and wage rate, upward linkage for technology, sectoral employment and labor force</td>
<td>Linked to central model through dual values of central resources and intermediate inputs</td>
</tr>
<tr>
<td>Investment choices</td>
<td>Not explicit</td>
<td>Not explicit</td>
<td>None</td>
<td>Irrigation</td>
<td>Canal linings</td>
<td>Land</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Livestock</td>
<td>Machinery and equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tractor</td>
<td>Land leveling</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power</td>
<td>Machinery and equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade</td>
<td>Aggregate growth. Not explicit for agriculture</td>
<td>12 crops</td>
<td>17 commodity imports</td>
<td>5 commodity imports</td>
<td>16 commodity imports</td>
<td>Not given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 livestock products fish</td>
<td>32 commodity exports</td>
<td>4 commodity exports</td>
<td>25 commodity exports</td>
<td></td>
</tr>
</tbody>
</table>
The method used in the Peru-Guatemala studies might be viewed as more akin to consistency analysis than simulation. Whatever the label used, the analysis was not as elaborate as that used for Korea. Korea was a second generation study, building on methods developed and lessons learned in a similar study in Nigeria.

The Brazil and Portugal studies are of the Samuelson spatial equilibrium type. The models encompass to some degree not only the agricultural sector, but also agricultural product processing, distribution and retailing, and transportation and port facilities.

The model for Mexico is part of a general economy system but with a small number of linkages. The agricultural sector model itself is not a fully spatial equilibrium type. Only production is uniquely specified by regions; demand is not. Thus, there are no explicit transportation activities.

The Ivory Coast Model followed the development of the one for Mexico and involved some of the same people. Although somewhat more simple in the crop dimension, it is used to analyze the agricultural sector through what may be called period dynamics, i.e., solutions for every five years through 1990.

All of these models represent attempts to go beyond the usual partial and/or static analysis; attempts to analyze the agricultural sector by modelling, various aspects of its complexity and its internal and external interdependencies. They differ in their coverage of emphasis and the methodology employment and consequently in their inherent economic analysis philosophy.
From the reports reviewed it appears that the models for Korea, Brazil and Portugal were subjected to the most rigorous validation tests, although that for Brazil was not judged to be satisfactory. As noted above these models' usefulness or reliability for agricultural development prescriptions is not known. In Korea, Mexico and Portugal they likely will provide some input into actual agricultural policies and programs in the future.

Prospective replicators of any of these models in other countries need to study them well and consider their attributes and limitations in terms of their own analysis objectives.
I. INTRODUCTION

The objective of this paper is to summarize the merits and limitations of alternative types of models that have been used to develop agricultural sector plans. In order to set the stage for this evaluation, general criteria, theoretical concepts and practical problems involved in planning—both national and sectoral—are discussed first.

The optimum planning models are, of course, the ones that produce the best plans; and the best plans are those that achieve implicit or explicit country objectives. Unfortunately, many development plans are not evaluated against achievement of a priori objectives. There are several possible reasons: First, it may be difficult to do so because objectives are not quantified; they may only be stated in qualitative terms. Second, plans may not have been implemented exactly as proposed because of political or other considerations, i.e., the "controlled" variables were not controlled as planned. Third, governments (planners) may not like to admit their failures.

Of the developed, non-centrally planned economies, the Netherlands probably has the best developed planning system, which, as is well known, was designed and implemented by Professor Tinbergen. The Dutch planning group, contrary to many, has a program to determine how well the plans have performed in terms of achieving target variables. Planning models have been improved as a result of these tests.
Terminology and Alternative Models

It has become customary for most economists to speak of normative and positive economic models. These labels have been used to describe, for example, linear programming and simultaneous equation methods, respectively. The term "normative" when used to describe linear programming does not strictly have the connotation as used by J. N. Keynes (7) 1/, "A normative science, a body of systemized rules relating to criteria of what ought to be, and concerned therefore with the ideal as distinguished from the actual, an art or a system of rules for the attainment of a given end." Normative, in the LP case, refers to an estimate of what would happen given certain goals, resources, and knowledge, where resources and knowledge may differ from reality. Also, normative analysis may prescribe what should be done, given certain means and ends, in order to maximize the ends. Thus, a normative model may be relevant in a country in which the government has a large degree of control over the means of production. A programming model may be structured to reflect such an environment because the means and ends are explicit. If the government has multiple ends, these can be handled by weighting.

Linear programming models employing customary profit maximization and other objective functions have been used to increase their ability to predict farmers' behavior. These efforts have not met with much success. For example, Lin, et al., (16) did some micro experiments (with actual farmers) to test the relative predictability of LP models using Bernoullian and lexicographic utility and compared the results with those of ordinary profit maximizing objective functions. They concluded:

1/ Refers to articles in Bibliography.
"None of the models predicted actual behavior well, with a strong tendency for all models to predict more risky behavior than was in fact observed. Profit maximization was the worst offender in this regard, consistently more risky than those actually followed. This may explain why standard linear programming (LP) results are often disregarded by farmers as 'unrealistic' and why aggregation of individual farm LP studies to predict industry behavior (e.g., supply function) usually have overestimated actual response." (16, p. 507)

Of course, factors other than risk, e.g., imperfect knowledge, may explain these imprecise predictions of farmer behavior.

Simultaneous equation equilibrium models are usually considered as in the realm of positive or behavioral economics: The usual objective of such models is to determine a behavioral structure of the economy and, given this structure, predict what will happen in the future. In the ideal case, such models are purely predictive. A purely predictive model would consist of a system that would estimate future endogenous variables from the lagged values of these same variables—lagged values may be from various periods of the past. Such a predictive or forecasting model has no use for economic planning, it is completely deterministic. To be useful, a planning model, no matter how simple, must include some instrumental variables—variables that the government can control and which in turn influence the course of the economic system.

Simulation models are very much related to simultaneous equation models. In cases where they depart, it is because the simultaneous equation model includes stochastic variables, usually estimated by some idealistic distribution function.
Any useful approach to national or sectoral planning must adequately reflect (model) the decision making milieu of the country involved. It must account for (a) the information base, (b) the private decision-making process, (c) governmental influence on private decisions, and (d) the decision domain of the Government itself. A good model also must incorporate a country’s private and public objectives.

To further explain these points, it may be helpful to refer to the planning procedure used in the Netherlands (12). Our illustrative model is:

\[ Y = Ax + Bz + Cd \]

Where \( Y \) is an estimated vector of endogenous variables, e.g., aggregate consumption, investment, etc., \( x \) is vector of lagged endogenous variables, \( A \) is a coefficient matrix that transforms the lagged variables into components of the \( Y \)'s, \( z \) is a vector of exogenous variables, e.g., taxes or world traded goods, \( B \) is the coefficient matrix for the \( z \)'s, \( d \) is a vector of government instrumental variables, e.g., factors that the government controls like the investments in highways, schools, the government budget for current expenditures and so forth. \( C \) is the coefficient matrix for the \( d \)'s. In this model only the \( d \)'s are relevant for economic planning. All the rest are not under the direct control of the government and planners. Under the Netherlands system available instrumental variables are used to try to achieve certain goals or values of target variables which are the \( Y \)'s or a subset, e.g., the level of employment or balance of payments equilibrium.
Any useful sector model must be developed under a similar, though not necessarily simultaneous equation framework. It must take into account the relevant variables in the system (in macro or micro form) together with their relationships; the model must be able to be linked with the government’s economics and other planning objectives.

**Relevant Dimensional Concepts in Sector Analysis**

In evaluating sector planning models, it is helpful to conceptualize the major dimensions of the economic system. For our purpose here, an economy is conceptualized in four dimensions: sectors, degree of processing (or level of fabrication) of basic resources, i.e., land, labor, minerals and water; time; and space. Such a system is depicted in Figure 1. Sectors can be further disaggregated in products or commodities. Thus, within each of these large cubes (Figure 1) there are literally thousands of commodities cubes and a smaller number of sector cubes. Commodities or sectors that appear on the bottom may not appear on the top. A sector may be differentiated only by the degree of processing. Final consumption may take place at any level of processing. On-farm consumption, for example, is at the first level of processing. Each product usually must go through the transportation sector to reach the next level of processing, though a few do not; and whether they are conceived to do so depends on the definition of processing. Of course, some items, like transportation and services, cannot be defined as to the level of processing or may be said to have only one level of processing. There is a multitude of linkages between the thousands of cells within the super cube and also between cubes representing different periods of time. Each cube can be thought of as a three-dimensional input-output system with
unspecified linkages. The purpose of this figure is to re-emphasize the complexity of even the simplest economic system and suggest the difficulties of modelling it.

Because the magnitude of the items involved is almost overwhelming, analysts are forced to work with some level of aggregation; even for some relatively simple partial analysis. Much analysis has been done without considering the aggregation problems that are involved primarily because aggregate numbers were readily available, but considerable insight into economic behavior or support for traditional theory has resulted.

In economic analysis for practical reasons, aggregation is done over decision units, over commodities, over space, and over time. Obviously, aggregation requires some weighting procedures for this adding up process. It does not make economic sense to add trains and trucks or potatoes and tangerines directly, even on a weight basis. Prices are customarily used. Costs may be used if prices are not equal to cost and if the type of analysis to be done so warrants. However, aggregation over products usually requires that prices be aggregated too. Aggregation over levels of processing is of a different nature. It may involve aggregation of widely dissimilar materials. For example, agricultural products may become part of an automobile. Many, many products and services may be transformed into one final product. When this is true, it will make sense to consider the final products as a unique sector and aggregate over inputs.

Quite a bit of work has been done on methods of aggregation, but only the surface has been scratched. However, both useful and useless economic analysis goes on using economic aggregates. The problem is that we don't
know whether bad analysis is due to bad theory or bad aggregations. Moreover, any economy, no matter how small and how controlled, is made up of thousands of decision-makers in addition to the economic dimensions just described that determined the path of the economy. These too must be reflected in the model.

This writer, after some conceptual struggling with the problem and some empirical investigations, has come up with the following rule of thumb for handling aggregation: "Disaggregate only to the level that answers are required, unless further disaggregation improves the precision of the estimates to a degree that warrants the increased cost."

Critique Procedure

As already noted, the fundamental test for any model is real world performance. Here a bad performance is defined as one for which the estimated achievement of the objectives or target variables differ greatly from the actual achievement. Unfortunately, adequate empirical performance tests, which require observations over time, are not available for some of the models being reviewed. We will have to base our critique mainly upon comprehensiveness, costs and reasonableness of the results in terms of logic, economic theory, structure of the models, and historical experience. This is not a good state of affairs but the only available practical procedure. Structure, comprehensiveness and reasonableness will be judged with respect to the concepts outlined in the previous section. Factors to be considered are the commodity, sector, regional, and time interrelationships and linkages. The importance of these linkages will depend on the nature of the analysis, and of course, whether it deals with a large or small segment of the economy. And this will determine whether a certain factor or variable should be considered exogenous or endogenous. To explain, let us take the case of
agricultural income vis-a-vis national income. In some studies, we may find that in order to estimate the demand for agricultural products, income is taken as fixed or exogenous. If the agricultural sector is a small part of the total economy, any variation in farm income generated by some policy will have only a small effect on total income and consequently demand for agricultural output. Thus, taking income as exogenous, or fixed, would not be a bad assumption. This point can be illustrated in the following diagram:

In this diagram, Sector B strongly influences by Sector A, but Sector A has only a minor influence on Sector B. Thus, any income increase in Sector A generates very little additional income in Sector B. Hence, for practical, simpler, analysis reasons this income linkage or feedback can be ignored.
Studies to be Evaluated

The following studies are to be evaluated in this report.


(2) A Planning Model for the Agricultural Sector of Portugal by Alvin C. Egbert and Hyung Kim (World Bank Staff Occasional Papers No. 20, 1975)


(4) Korean Agricultural Sector Study (Korea, Agricultural Sector Study Team, Agricultural Economics Research Institute, Ministry of Agriculture and Forestry, Seoul, Korea, and Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 1972)


(6) Inter-Dependence in Planning; Multi-Level Programming Studies of the Ivory Coast, by L. N. Goreux (mimeo, IBRD, 1975)

II. THE PERU AND GUATEMALA STUDIES

The Peru and Guatemala studies ((1) above) do not employ agriculture sector models per se. To a limited extent the studies used the methodology of Tinbergen plus some auxiliary models to focus on and forecast employment in 1985, emphasizing unemployment in the agricultural sector. The total analysis might be characterized as eclectic and informal. It is reviewed here for contrast to the other more formal models.

Objectives

The authors state (page 142): "The Main objective of the projections were, first, to formulate a consistent methodology which would measure
the productive labor absorption capacity of sectors as a function of aggregate and sectoral output growth and, secondly, to apply the methodology to both countries to estimate the magnitude of future un- and under-employment—particularly in agriculture."

**Methodology**

The methodology, too, is not succinctly presented. The following interpretation represents some reading between the lines.

The first step was to use a macro-economic model to help project general economic growth through 1980. (The model specifications are not given; the authors referred readers to reference (1) for an idea of the model’s structure.) Because exports are exogenous in the model and loom so large as a determinant of economic growth, the next step was to do an independent commodity by commodity projection of export growth. Apparently, because of the uncertainty of export growth and the tenuous structure of the basic model, three alternative economic growth rates of 4, 5 and 6 percent per annum were assumed for analysis and projections.

The general economic growth rates were translated into sectoral growth estimates using judgemental values for elasticities between sectoral and national growth rates. Next, increasing labor productivity rates by sector were hypothesized which permitted the derivation of labor requirements (or employment) sector by sector for each of the three growth rates.

The authors summarized the procedure as follows (p. 58):

"In summary, the methodology used to project labor force sector by sector was first to select likely growth rates for the economy as a whole, secondly, to devise the corresponding growth rates of sectoral value added, and finally, by making some hypotheses about changes in labor productivity by sectors, to compute corresponding growth rates in the sectoral labor force."
These estimates provided a rather dismal picture for under- and unemployment through 1980; therefore, a more detailed analysis of potential employment in agriculture was done. Three alternatives were considered:

(a) no change in production technology;
(b) increases in biological technology but no change in mechanical technology; and
(c) increase in both biological and mechanical technology.

Projection for agricultural employment were made essentially on a commodity by commodity and, subsector (domestic food and export crops) by subsector basis. The methodology used for Guatemala essentially consisted of the same procedure.

Results

The report presents forecast for 1975 and 1980 for 12 macro sectors. Items included in these forecasts are population and labor force for rural and urban groups; growth rates, in value-added; labor productivity; and labor force for each of the 12 sectors for 3 alternative rates of growth in total GNP, and also projections of the absolute level of employment for the 12 sectors.

Because these over-all projections resulted in a low rate of growth for agricultural employment, a further analysis was done for agricultural in which 3 alternative, production technologies were considered. It was found that another alternative, technology II—improved biological but with no change in mechanized technology—gave the highest growth in agricultural employment. 1/ However, even this alternative only gave effective employment

1/ Only one general growth rate was used for all agricultural technology alternatives.
rates of 66 percent and 63 percent in Peru and Guatemala respectively. It should be noted that no attempt was made to assess the "secondary" impacts of the alternative rates of growth of agriculture resulting from these alternatives on other sectors of the economy.

**Evaluation**

The methodology includes the total economy, but a relatively high level of aggregation. Although, all sectors of the economy are included, all sectors are not rigorously linked. However, a "consistency" analysis was made using a 1963 level input-output model, assuming no change in input-output coefficients. The consistency results were not especially good or bad.

The methodology probably is best characterized as conditional or comparative statistics. Overall growth—three alternative economy-wide growth rates and three different agricultural technologies—is analyzed with respect to their impact on the level of employment. No prices were included in the analyses.

The question is: Is this analysis adequate (gives answers with an acceptable degree of precision) in the light of the stated objectives: to measure the labor absorption capacity of sectors and to estimate the magnitude of future un- and under-employment, particularly in agriculture? Come 1980, some would say that the study is adequate if indeed un- and underemployment is higher than at present, as the study forecast. Others would say, a good (precise) estimate of the magnitude of the problem is needed. The precision of the forecast can only be determined in 1980. But precision in a forecast cannot be assessed by one observation. Because of the time periods involved in long-term forecasting analyses, repeated
testing is not practical. One practice that is used is to derive the parameters of the model in one historical sample periods, then test it with another historical period. Such a procedure is not practical in countries which do not have long historical data series.

Alternatively, one could make some judgement of the precision of the model by relating other components of the model, e.g., overall growth, exports and so forth to reality. Thus, it could be determined whether the employment forecast might have been right for the wrong reasons.

Depending on one's view point, one large defect in the model is that it does not include a structure for designing and implementing remedial action. That is: given that full employment is a relevant social objective, the model "is incapable" of prescribing programs that would achieve that goal. This is only to say that the model's usefulness would have been improved if such a structure or mechanism had been a part of it.

III. PLANNING AND DEVELOPMENT MODELS FOR THE AGRICULTURAL SECTORS OF PORTUGAL AND BRAZIL

These two studies are generally related; hence they are reviewed together. The reader has already been alerted that the writer, because of his involvement, may not be able to present a completely objective review of these projects.

It should be stated at the outset that these two agricultural sector models were developed as normative, deterministic and indicative planning analyses, which given the goal implicit in the model--economic efficiency--provide only the blueprint for achievement, not the means.
Objectives

The studies were undertaken under a research program entitled, "Evaluation of Alternative Methods of Sector Analysis." The Brazil report states, "The Study reported here represents part of a research project to evaluate alternative methods for specifying comprehensive agricultural sector development strategies." Among the specific objectives are: (1) to compare the results obtained from this study with other methods, such as sector surveys being conducted by the Bank, and (2) to determine methodology by which sector surveys can be improved within given time and resource limitations." On the other hand, the Portugal report states, p. 3, "The general objective of the analysis was to determine whether a certain type of model could produce better insight into the mechanics of agricultural development [than conventional methods], one that would lead to the design of improved agricultural development strategies and programs." Obviously, because the separate country analyses were part of the same project, the objectives could have been stated more uniformly. In fact, at the inception the project's objective was "to compare alternative methods of analysis as instruments for sectoral development and project appraisal." With respect to procedure it was stated, "several methods will be investigated and each investigation may proceed concurrently but under close coordination. Tentatively, the methods to be analyzed are mathematical programming, contemporary econometric methods and simulation techniques. In each of these alternatives, there will be a concerted effort to relate and compare each method in terms of: (1) data requirements and availability, (2) realism and usefulness of the results, (3) cost of the analysis, and (4) feasibility of implementation."
The Portugal study never got beyond comparing the results of mathematical programming and general sector reviews undertaken by the World Bank and doing an eclectic projection for the country for 1980. The other methods of analysis never came into play because after data requirements and their availability were reviewed mathematical programming appeared to be the only method feasible under the budget and time constraints.

Methodology

The methodology employed in the Brazil and Portugal Studies were essentially the same; only the commodity set, transportation structure and size of the economy differed. The conceptual framework employed was a spatial equilibrium programming model which was first outlined by Samuelson in 1952. (16) Advancements in linear programming and computer technology since that time have made it feasible to apply the concepts developed by Samuelson to complex empirical studies. The objective of the empirical model was to determine for each region the production and consumption mix of agricultural products (domestic and foreign) that will maximize total social payoff, given the level of consumer’s income, the cost (both direct and opportunity) of production, cost of transportation between markets, and net trade price. The solution to the model is such that the selling price of each final product is equal to its total marginal cost including that for production, processing, handling, transport and selling. In other words, the model simulates a perfectly competitive market given the resource constraints, production coefficient and demand structure. As such it provides a solution that maximizes welfare given the income distribution.
In the following section, the results of the Brazilian model are discussed first because they were less acceptable, due to basic data problems. Therefore, we present the empirical structure of the Brazilian model followed by that of Portugal and then summarize the results of these models in the same order.

**Empirical Structure of the Brazilian Model**

The structure of the Model can be best summarized by resource constraints and production activities.

Fifteen basic required resources constrained the solution to the model. These constraints included labor, mechanical and animal power, chemicals, veterinary services, livestock inventory, three classes of land, transport capacity, and warehouse and port capacity.

Thirty-one types of agricultural production activities were included in the model—six for livestock and 25 for crops. Three alternative techniques were assumed for all production activities. These techniques represent different input mixes and factor productivities, with the lowest ordered technique utilizing mainly land and labor, and highest utilizing tractor power and a large amount of purchased inputs. The intermediate techniques also use some purchased inputs but employ primarily animal draft power instead of tractor power and consequently employ more labor than the high technology alternative.

Because a spatial equilibrium model was used for analysis, Brazil was divided into 13 relatively homogenous regions. Unique production activities and resource constraints were specified for each of these regions. However, due to climatic limitations a full set of the production activities was not specified for each region.
The model also included activities for transforming primary products into consumer goods. There were also activities to transport all primary, intermediate and consumer products from each region to every other region. The model provided for the transportation of labor, too, from each region to every other region.

In order to provide competitive prices equilibrium solutions, the model included demand functions for each of the 39 final products sold in each region. There were 32 activities providing for the export of agricultural products and 17 activities providing for agricultural imports. Each of these activities was constrained by quotas, which were based on historical levels. These constraints were necessary because import supply and export demand functions were not available; consequently, in the model imports and exports take place at constant prices.

Empirical Structure of the Portuguese Model

The most significant different between the Brazilian and Portuguese Models is the constraints or limits on transport, ports and port warehouse capacity. These resources were judged to be adequate in Portugal vis-a-vis others such as land and processing facilities.

The resource constraints in Portugal Model included labor, tractor power and machinery, animal power and machinery, all specified by quarters of the year; three classes of open land and three classes of land with trees and vineyards, six classes of livestock, six types of processing plants for livestock products and meat cold storage capacity.

Thirteen primary crop products were produced by activities that simulated crop rotations and three which produced fruits assumed continuous cropping. Five livestock activities produced animal power and primary
products, which together with processing activities, provide six animal products for final consumption. All together the programming system produces 19 crop and livestock products for final consumption or export.

As with the Brazil Model, price dependent demand functions were specified for each of the products by region. Transport activities provided for the shipment of all primary, intermediate and final commodities between all regions.

Imports in the model consisted of five agricultural commodities, high protein feed and potash fertilizer. Four agricultural products were assumed to be exported.

Results

The Brazil Model

Results were obtained for two basic models for Brazil. In one, the country was divided into 11 contiguous regions. In the other, these 11 regions were aggregated to form 6 contiguous regions.

The 11 region model, given the computer system available at that time, was difficult and costly to solve. Consequently, only one analysis was made with this model. The following analyses to test the sensitivity of the 6 region model were done:

1. Higher levels of processing, port and storage capacity and volume of foreign trade;
2. Value added in agriculture increased by 20 percent above base solution;
3. All prices of inputs used by farmers in the Northeast area are reduced by 20 percent, i.e., are subsidized. This area is traditionally low income;
(4) Increased values for maximal export;
(5) Same as (1) but with no change in processing capacity;
(6) Larger processing capacity;
(7) Higher rural employment in Northeast Brazil;
(8) No trade permitted between Northeast Brazil and the rest of the country;
(9) All agricultural labor is valued at a minimum supply or reservation prices.

An attempt was made to validate the 11 region model for 1966, for which the most adequate data was available. The results showed that the programmed output was generally higher than actual output and consequently prices were generally lower across regions. Thus, it was concluded that the basic production data (either the resource levels, input-output coefficient or both) in the model were incorrect. This is, as noted earlier, a moot point, i.e., whether indeed the model is behavioral. If it is not behavioral then it must be validated on the basis of its objectives and its achievement thereof. The model, as stated before, is some of both. The consistency of programmed production being higher than actual production seemed to indicate that production costs for constraints were incorrect. Hence, the usefulness of model for policy analysis is limited.

Sensitivity analyses were carried out with the 6 region model for methodological purposes to determine what types of the analysis and what types of information can be obtained from the model; also, what changes in the programming results occur when regions are aggregated?

In general, the results obtained from the sensitivity analysis were informative and as expected. We only summarize the first three sensitivity tests noted above.
Sensitivity analysis (1) had little impact on the programming solution. The net social payoff increased by 1.8 percent and agricultural value-added changed minutely. Production of most crops in most regions generally increased. The greatest changes occurred in trade.

Sensitivity analysis (2) yielded the 20 percent increase in value-added through contraction of products that have a low price elasticity in consumption. As a result, the net social pay-off of the solution decreases.

Under sensitivity analysis (3), only small changes in the model solution result. This was the case because resource constrains and not cost affect the solution most.

The sensitivity results point up the several data deficiencies in the model as mentioned above.

The results of the aggregation comparisons were similar. The aggregate solution for the 6 regions were similar to that for 11 regions. Again it was concluded that these consistent results stem from the nature of production data or basic input-output coefficients.

The Portugal Model

The Portugal Model was validated using 1968 as a base. For validation purposes, actual data were compared with programmed data using the Theil U coefficient. When this coefficient is zero, all estimated data used in comparison are equal to the actual data. This coefficient multiplied by 100 is equal to the average percentage error in the estimated values. The range of U for comparison of programmed and actual production region by region for a specific commodity ranged from 0 – 55 and for total production it was 8.5. Similar comparison for per capital consumption, and prices results in about the same range in U coefficients.
As noted before, because of model imperfection, uncertainties and lack of knowledge on the part of producers as well as other factors, the correspondence between the estimated and actual is not expected to be perfect. It was concluded, therefore, that the model sufficiently represented the structure of agriculture and related sectors that it could be used for planning analysis.

After this validation or verification, the model was used to compare the results of the 11 region model with that of a 3-region model which was an aggregation of the full model. The results of the two models were significantly different, especially for foreign and regional trade. Thus, it was concluded that simple aggregation (averaging) procedures in models of this type could lead to wrong planning presumptions.

The model was also used to specify development plans for the agricultural and agricultural product processing sector of Portugal using 1980 as the target year. These development plans could inter alia consist of investments in irrigation development; farm machinery, buildings and other equipment; improved livestock herds; and current expenditures for improved seeds, fertilizer and other modern farm inputs. It was presumed that the development would be implement through farmer profit incentives augmented by government programs and investments where necessary. Government intervention would be essential for irrigation development.

All of the development programs were determined to be economical except for irrigation. This result was due, most likely, to the fact that irrigation requires a high initial investment and yields a long-term pay-off. Moreover, other short-term types of investments appeared to be more economical for providing Portugal's food needs through 1980. Also, though
the specified investment program marginal lands could be converted from food production to forestry, imports could be reduced, and real cost of agricultural products and food lowered.

Evaluation

Two signification limitations of the Portugal and Brazil models are their static nature and their limited linkages to other sectors of the economy. Further, the Brazil model lacked a good data base. Each model was planned to be used for comparative static analysis. However, only the Portugal model achieved this objective. The Portugal model was directly linked to the processing sector and the Brazil model was linked to transportation as well as agricultural goods processing. Neither model had a feedback loop with the general economy, however. This omission could lead to some distortions in the results, but is conditional on the proportion of the total economy that agriculture represents. In Portugal, it represents about 14 percent and in Brazil about 15 percent. Thus, this lack of linkage may not be a serious limitation. However, more studies are needed to determine the loss of information that occurs when linkages of such magnitude are ignored. Moreover, these linkages need to be cast in a dynamic time frame.

On the positive side, the models are completely spatial, that is, all of the variables are defined with respect to specific regions. All data are location specific: production, consumption, income, investment, and all trade flows. Thus, the models answer the question: what, where, how and when. However, the prescriptions the Portugal model provide (none were made with the Brazil model) must be tested in the crucible of development experience before a final judgment can be made. Theoretically, the models have both positive and negative attributes that need further empirical evaluation.
IV. KOREAN AGRICULTURAL SECTOR STUDY 1/

The Korea report (8) represent a second generation study that has been carried out by a team of researchers at Michigan State University in close collaboration with officials and researchers in Korea. A similar study of agriculture was done in Nigeria. Though some facets (methodology) of the Nigerian study were more highly developed than those of the Korean Analysis, on the whole the Korean study reports a higher level of conceptualization and analytical development; consequently it is reviewed here.

Objectives

The objectives of the study, in abstracted form, were:

"(1) To recommend strategies, policies and programs to achieve specific development goals for the agricultural sector that are consistent with national values relative to food self-sufficiency levels, improved rural life, upgraded contributions of agricultural sector to the general economy, and administrative and political stability.

(2) To provide Korean agricultural policy policy makers with insights into the economic and social consequences over a 15 year planning horizon of following alternative strategies in developing Korea's agricultural sector.

1/ The study reviewed here reports on only the first phase (first 7 months) of a 5- to 6-year sector modelling and implementation program in Korea by a Michigan State University Team. The final result, especially the quantitative part, of that program was not available at the time of this review.
(3) To provide ... a comprehensive study and analysis of the components comprising the agricultural sector ... and to make recommendations relative to those changes in policy, programs, investment, organizational and other areas necessary to obtain and sustain a given agricultural sector growth rate.

(4) To make a preliminary identification of priority investment areas...

(5) To improve and develop the capabilities of the ministry of agriculture and forestry in program evaluation analysis, program development and policy formulation ... ."

Indeed, the above is an impressive and challenging list of objectives; the complete list is more so. The complexity of the methodology employed reflects the comprehensiveness of this list.

Methodology

According to the authors the Korean Agricultural Sectors Study (KASS) Model is difficult to describe (8, p. 45). They say that this is the case because it is a general model. It has been characterized in several places as a Generalized System Simulation Approach to Agricultural Sector Analysis.

This phrase has a very complex meaning in this study. Briefly, but perhaps inadequately, this Generalized System Simulation Model includes the following elements or concepts: (a) an eclectic general approach, i.e., selective use of the best available methodologies and procedures; (b) a system that encompasses, depends on and promotes subject matter, disciplinary and problem-solving research; (c) an integrative, interactive approach to pre-
maximization work that involves both researchers and decision-makers; (d) institutionalization of the system within the decision-making environment by establishing an agricultural planning project within the Ministry of Agriculture and Fisheries that would develop and integrate the Ministry's planning capability.

On the formal side, one of the objectives, or objective, of the approach, is to develop a logical framework or systems model which takes account of the structure, process, and interrelationships of the total agricultural sector and its interaction with the rest of the economy and which is capable of addressing a broad set of problems related to agricultural sector development. In this review, we only look at the preliminary numerical results that relate to the agricultural sector and that were generated by the total systems analysis. It was impossible from the report available to review the total system itself.

The agricultural part of the model is very complex. It is represented by more than 140 equations and/or mathematical relationships. Nineteen explicit commodities or commodity groups are included. Each of these has specifications for price, acreage, yield, production, imports, exports and consumption; all by rural and urban categories. Other variables include population and employment by rural and urban groups (rural-urban migration), urban expenditures on food and non-foods, gross agricultural income and product income for agriculture per man year and per acre, expenditure for farm inputs which include fertilizers, pesticides and feeds. Long term capital analysis with these basic economic variables was done with 3 alternative policy strategies.
Briefly, these strategies were (8, p. 60):

"Alternative I: A continuation of the agricultural policies and rural development strategies laid down in Korea's Third Five-Year Plan (TFYP) which contains these specific goals: (1) increasing the production of agricultural products with an emphasis on attaining self-sufficiency in food grains, particularly rice by 1976, (2) increasing incomes for farmers with an emphasis upon narrowing the farm non-farm income gap, (3) establishing an expanded agricultural production base and (4) improving the quality of rural life..."

"Alternative II: General development objectives are the same as for Alternative I, but to speed up development the following programs are included or emphasized:

(1) Improvements in research and extension education with emphasis on areas thought to have high marginal returns to research and extension;

(2) Close control of land and water development projects to concentrate on high payoffs;

(3) Still higher rice prices than in the original Third Five-Year Plan (TFYP) to provide an incentive to expand rice production and reduce consumption;

(4) Emphasis on mechanization and needed to fill labor gaps;

(5) Increased investment in population control over the original TFYP plan along with population dispersal; and

(6) Concentration on infrastructural programs that will eliminate transportation and marketing bottlenecks to agricultural development.

Alternative III: Under this policy strategy set, greater reliance is placed on the competitive market to allocate productive resources and ration goods to consumers. Market equilibrium prices are assumed without government price support or subsidy intervention, except for stabilization purposes, in either the agricultural input or product markets. World market prices provide the base for a major portion of the domestic price structure and the price level for agricultural products and inputs. (The exchange rate was assumed at 450 Won = US$1.) Other unique features are: (a) Resource transfers are provided to the agriculture sector via government supply of low-cost credit funds. (b) Long-term land and
water development projects are undertaken under government leadership, with government providing long-term financing at low interest rates. (Loans would be paid off by project beneficiaries.) (c) General agricultural policies designed to develop the agricultural sector through investments in infrastructure and institutions, better control of food quality standards, industrialization and population dispersion policies to develop sources of non-agricultural income in rural areas and transition policies to ease the economic and social consequences of adjustments to new policy strategy. (d) The transition to a domestic and world free market will take place over three to five years."

Under these three alternatives, projections are made for 1975, 1980, and 1985. These projections were made with the assistance of the formal set of 138 equation as noted before. Because of the model specifications some of the endogenous variables in the model could not be solved simultaneously and both internal and external iterations had to be carried out. The basic "iterative" exogenous variables are commodity prices and land planted to each crop by region. The final forecasts by the model include:

(a) Total production by enterprise and regions (three regions--single crop paddy, double crop paddy and upland), seasonal production;

(b) seasonal labor requirement;

(c) farm consumption and storage;

(d) farm sales;

(e) gross income by crop, by region, and for the total country;

(f) demands for expenditures on inputs by type, by crop, by region and by sector;

(g) gross profits by enterprise and by region;

(h) returns above land and labor;

(i) returns to land and labor by crop and by region;
(j) gross income per capita by region;
(k) per capita rural intake of calories and protein.

While considerable data values were generated within the formal simulation model, a large part of results were derived externally and based to a considerable degree on judgments and separate analysis. The most important of these are nonagricultural income, crop yields, land allocation to particular crops and the type and level of investment in agriculture.

Results

Only selected items in the large amount of data and information resulting from the analysis can be mentioned. Important ones are:

(1) Population in Korea by 1985 under alternatives II and III, which include strong population control programs, would be about 1.5 million, or 3.5 percent less than that of alternative I. Employment and unemployment would be largely unaffected because the people making up the labor force of that period have already been born.

(2) Agricultural income would be highest under alternative II and lowest for alternative III. Under alternative II, the total income would be about double that estimated for 1971. A large element in these income differences is due to the price levels resulting from the different programs.

(3) Because of the difference in the price and income levels, consumption and nutrition of rural people is highest for alternative II. For urbanites highest for alternative III, but lowest for alternative II. Because nominal urban incomes are assumed to be unaffected by farm policy strategies, there is a transfer of real income from rural to urban people in moving from II to III.
(4) Under all three alternatives the percentage of income spent on food by urban people was projected to decline from 1971 to 1985. Under alternative III, this would amount to 30 percent.

(5) The net foreign exchange deficit for food increases under all three alternatives but is least for alternative II rising from 80 billion won in 1971 to 100 billion in 1982.

It is concluded that alternative II results would be more consistent with general goals of the Korean government for agriculture and rural people.

Alternative II was used to do some sensitivity analysis using different income elastacities and rates of income growth in the urban areas.

Evaluation

The Korean Agricultural Sector Study represents an attempt to analyze and prescribe policies and programs for agriculture in a comprehensive and complex analysis framework. No attempt is made to maximize an "objective" function in a mathematical sense. But it is maintained that alternative II yields the best results from the viewpoint of judgments arrived at by the interactive-iterative process carried out by the research team and government decision-makers. In a sense then it represents a "maximum" for the three alternatives.

While the analysis includes variables representing most of agricultural and its linkages with non-agriculture, the study was not successful in encorporating them in one complete computerized system. These are technical considerations. The critical issue is whether results would be obtained if the prescribed policies and programs were implemented. Moreover it is not certain that the policies and programs considered are implementable, i.e., if
alternative II for example was selected, that it would be carried out within the present institutional framework of Korea. The authors put it this way (p. 92):

The projected advantages of alternative II over alternative I and the fact that current policies are moving toward alternative II in the area of grain prices speaks well for current Korean decision making efforts. However, projected results are not actual results. The question remains as to whether these results would actually be attained.

Alternative II would be expected to correspond more closely to reality than those for the first alternative. Reasons for this include more reliance on price incentives and free markets than on exhortations to increase production and bring consumption into line with production and, hence, less reliance on poorly coordinated public agricultural and home affairs agencies. Thus, while there is some basis for expecting alternative II projections to be more fully attained than those for alternative I. However, it must be pointed out that alternative II relies on effectiveness of governmentally operated family planning programs and does not specify whether or not the markets for modern factors of agriculture will be publicly or privately run. If it is assumed that the later are turned over, increasingly to private hands, the projections for alternative II are more likely to be attained than those for alternative I.

Thus, we see that there are considerable uncertainties in alternatives I and II even if one or the other represents the actual program of the government. (Alternative III, as noted, would be unacceptable to Koreans because of the estimated consequences).

It should be noted that the study reviewed was "quickie" in nature. Although exact dates are not given in the report. It might be inferred from the fact that projections for 1971 are given in the report and the final report is dated 1972 that that study was initiated in 1970 and completed in 1972. Although a foreword to special reports states that the study was "completed between September 1971 and July 1972." It is not clear what is meant by this statement. Does "completed" equal "done"? Because of the relatively short time available to present this first report, testing of the
model results against past behavior of the sector was not done. This, as noted before, is a necessary though not sufficient part of validation. It is necessary to determine the degree of forecasting ability embodied in the model. A good historical fit will be a good test of a model if the structure of the economy or subeconomy remains the same over-time. It will not be a sufficient test if the basic structure of the economy changes. But a historical "tracking" test is preferred to a simple judgemental validation. Because of the "forecast" years of 1971 and 1975 are history it would now be possible to compare this forecast with what has happened, assuming, of course, that relevant data are available and a relatively comparable "policy set" was implemented.

The problem of modelling reality and validation will come up against our review of other sector analyses.

On the positive side the study does forecast the consequences of alternative agricultural policies and programs in a comprehensive and realistic framework. It incorporates both public and private decision processes in the forecasting system. It accounts for all the factors that impinge on development in the agricultural sector, some in a formal way, other informally. As noted, work has continued on methodological development of the system. Unfortunately, the latest results were not available at the time of this review. A book summarizing most recent results is in process.

V. MULTI-LEVEL PLANNING: CASE STUDIES IN MEXICO

In this study the Mexican economy, as the title implies, is analyzed at several economic levels - total central economy, sectoral, and subsectoral. However, sectoral and sub-sectoral analyses were done only for energy and
agriculture. The analytical approach followed recognizes the fact that economic change and development sector by sector and commodity by commodity are inter-dependent.

In addition to the two editors, Goreux and Manne, fifteen others contributed to the compilation of the book and undoubtedly many others contributed to the analysis. In one sense the book consists of a set of separate essays that are related by certain linkages to a certain conceptualization of the total economy.

Objectives:

The editors say (page 1): "Inter-dependence in planning is the central concern of this monograph. The problem is analyzed through a system of optimizing models corresponding to three levels of aggregation." But on reading the book one concludes that the objective was more than that.

On page 292, it is stated:

"Therefore the initial aim of constructing the agricultural model CHAC was to formalize the major aspects of micro-level and sectoral decision-making. In keeping with the orientation of this volume the broad theme of the agricultural studies is linkages between different levels of decision-making. But as usual in model-building there is more than one underlying purpose. The sector study has also been designed to serve both the Mexican Government's interest in analytical tools for planning sectoral policies and the World Bank's interest in methodology of project appraisal techniques and in general policy planning models."

Methodology

The reason for doing multi-level planning is pragmatic. Goreux states:
"In this volume the inter-dependence of economic decisions is studied in two ways. The first consists of progressively enlarging the scope of the model. (It is not clear whether this means disaggregation or moving from a partial system to a general system, with or without aggregation.) This approach is rigorous but it is very expensive in terms of data collection. Moreover, the scope for enlargement is limited by the size of models that computers can solve and economists or policy makers comprehend. The second approach is to build several models, each self-contained, and to establish some linkages between them."

The basic method of analysis used in these multi-level planning studies is linear programming (or non-linear problems approximated by linear formulations). Seven distinct models make up the study:

Two economy-wide models - DINAMICO and EXPORTA: DINAMICO, as implied by the name, is a dynamic or time-phased model. EXPORTA, on the other hand, is a single period, static model which emphasizes the export sector.

Two sectoral models - ENERGETICOS for energy and CHAC for agriculture. ENERGETICOS includes electricity; and petroleum production and refining. CHAC is only a partial agricultural model as it includes only the most important short-cycle crops, numbering thirty-three, and no perennial crops or livestock.

One sub-sectoral model for energy - INTERCOM. (For some reason, or reasons, the results obtained for INTERCOM are not presented in the book.)

And two sub-sectoral models for CHAC: BAJIO, an agricultural sub-model that is used for a detailed investment analysis in a single district and to test linkages with the sector model CHAC. PACIFICO, another sub-model is used to test and develop decomposition procedures.

Explicit linkages between the national model, DINAMICO, and the sector models, ENERGETICOS and CHAC, are few and in some instances one-way--e.g., shadow prices of capital and foreign exchange are transmitted downward to ENERGETICOS and there is no feedback information transmitted upward to DINAMICO. Shadow-prices of foreign exchange, the interest rate,
wages and income are transmitted downward to CHAC. Then alternative technologies, level of employment, and the labor force are transmitted upward to DINAMICO for the next iteration. The process is repeated until assumed "exogenous" values and the internally derived "endogenous" values converge. Iterations were not done for ENERGETICOS because of disaggregation problems and weaknesses in the linkages.

Iterative solutions are fundamental to multi-level planning procedures. All possible technical substitution possibilities could not be included in the total economy model DINAMICO because of its large size. Such details can be included in sub-models but the sub-models require certain information such as the foreign exchange rate that is endogenous to (is determined in) the total model but not in the sub-model because the final (equilibrium) rate is jointly determined by all sectors or sub-models. Thus, iterations are, as noted above, required between the total model and sub-model during which certain information is passed back and forth at each iteration until the transferred information does not change between iterations, i.e., the solution, for N-1 is the same as for N, the last iteration.

Results

Because this review is mainly concerned with sector models, this section will only cover the results of the agricultural sector models CHAC, BAJIO, and PACIFICO. We start by summarizing the results of CHAC solved independently of the total system then move to the results derived by its linking with DINAMICO. Of course for complex models such as CHAC, all results cannot be presented without overwhelming the reader and rendering the results unintelligible.
The results of CHAC relate to two periods, the base period 1968 and a future period 1974. (Work was initiated around 1970). Four types of results are emphasized - international trade, income, employment and technology. These results are summarized for the base period 1968 and the projected year 1974. Data are only presented for all districts and comparisons were made of projected growth rates with historical rates when they existed. One important result is the fact that farmers' income is projected to grow less rapidly than average national income (the latter is an assumption in the model). It is concluded that this result and others may be unrealistic because (a) the income elasticities may be underestimated, (b) the investment activities may be misclassified in a manner such that investment is overstated, (c) the export market potential may be underestimated, (d) the yield-enhancing effect of disembodied technical changes may be overstated. These reasons are qualified with the statement that there are no direct estimates of income originating in agriculture.

The basic model was next used to analyze several policy instruments which included foreign exchange premiums, interest rate changes, wage changes, a surcharge on irrigation water and government-supply control.

The general conclusion resulting from these policy instruments was, within the context of the model, that individual impacts are not additive, i.e., the separate effects of foreign exchange premium and wage changes do not add to the total effect when both are implemented together. Moreover, each of the implemented policies have both positive and negative effects on target variables. For example, a foreign exchange premium of 30% increases sector income by 3,478 million pesos, net exports by 1,731 million pesos, employment by 30 man-years, but decreases the consumer surplus by 2,754 million pesos, and increases the budget by 2,446 million pesos.
Even though all items except employment are measured in pesos, it cannot be concluded that on balance the net effects are positive and by how much. For example, the foreign exchange earned (peso equivalent) by agricultural exports may be worth more or less than a peso depending on its final use, i.e., imports of high productivity capital goods or luxury consumer goods. It should be noted too that these are static comparisons assuming alternative policies within the same year. The dynamic effects will be different. Also the cost and benefits are not mutually exclusive. Producers pay taxes but producers are also consumers who may receive some benefits from the taxes.

**Analysis of BAJIO and Its Linkages with CHAC.** As noted above, this sub-model was designed for detailed investment analysis at the level of an agricultural district. The types of investments analyzed include linings for existing canals, installation of new tubewells and leveling of land. In BAJIO there is much more data detail than for the districts that make up CHAC. The major differences in the separate BAJIO model are: (1) the number of farm types; (2) the management skills defined; and (3) the number of technology options.

For linkages of this model with CHAC, both BAJIO and CHAC were aggregated to form BAJITO and CHAQUITO. The reader is not told the dimensions of these reduced models; their original sizes are: BAJIO, 380 rows x 800 columns and CHAC 1500 rows and 3400 columns. Three types of solutions were obtained for BAJIC—(1) with average 1968 prices, (2) with prices obtained from the solution to CHAQUITO and (3) with BAJITO as a part of CHAQUITO. In most instances the solutions for the latter two are about the same. They differ slightly because, as the authors say, there are joint
products in BAJIO but not in BAJITO as a part of CHAQUITO. The solutions for BAJITO with average 1968 prices differ significantly from the second two because relative prices differ and average prices are higher.

Sensitivity analyses are made with each model with all possible combinations of: (1) with and without a foreign exchange increase of 30 percent; wages at either 13.5 or 19.5 pesos per day and interest rates at 12 or 24 percent.

As is expected, higher wages increase investments because machinery is substituted for labor and higher interest rates reduce investment as the opposite substitution takes place.

The authors state (page 433), "The results of BAJITO are difficult to summarize..." but then go on to say that it is a workable model for formulating investment plans for a particular district if adequate price forecasts are available.

Linking CHAC with DINAMICO. The Linkages between CHAC and DINAMICO are limited. CHAC receives from DINAMICO (called DINAMICHAC when they are interacting): (1) interest rate; (2) foreign exchange rate; (3) income growth; and (4) wage rates. CHAC passes to DINAMICHAC: (1) alternative technologies (input-output ratios); (2) sector employment rate; and (3) agricultural labor force. Four alternative solutions are obtained for DINAMICHAC; these include combinations of technology, labor force, and the employment-output ratio of 1968. The combinations arise out of the use of data obtained by solutions to CHAC or DINAMICO.

The results of these four alternatives are difficult to summarize. Case 1 involves the basic solution for DINAMICO and includes a constant marginal rate of substitution of capital for labor (technology), a labor force
of 7.024 million and 100 percent employment. GDP growth averages 6.91 percent per year under this alternative. When the CHAC solution technology is employed in DINAMICHAC, Case 2, GDP growth falls to 6.69 percent per year. Case 3 includes the technology from DINAMICO, a large labor force which yields surplus labor for the economy. GDP growth in this case is 7.3 percent per year. When CHAC technology is assumed for DINAMICHAC, there is little change in the growth of GDP and the level of investment as well as other endogenous variables.

The authors label these results with multi-level model linking as experiments. A number of problems surfaced: The DINAMICHAC growth rate of Case 4 is not the same as the growth rate used in CHAC, 6.9 cf. 7.3. Thus additional interactions would be required for agreement or consistency. There is also no consistency in wage treatment and so forth.

These experiments do point out that macro models do submerge some of the options for development that are important and can be considered in less aggregative models. They also point out that there are no simple practical methods for economic planning.

We conclude this section by noting that experiments in solution to such large LP model like CHAC by decomposition were done with a hypothetical model PACIFICO. The main conclusions of this experience are:

(1) "If a linear programming model is to be solved by decomposition, substantial savings may be obtained by examining the structure of the problem for relationships which could influence the computational procedure, and (2) from these experiments no direct conclusion may be drawn concerning the decision to decompose or not to decompose. This question is highly dependent on the problem at hand."
Evaluation

This book summarizes a significant effort to implement the concept of multi-level planning or modeling. It falls short of the conceptual ideal in two ways. First, the sub-models are not completely integrated into the total economy model and, second, a complete set of submodels was not constructed. The authors state in effect (page 11) that the five models belong to a loosely connected system. But also these models are not conceptual homogeneous in terms of aggregation. They do not represent mutually exclusive systematic aggregations. ENERGETICOS by some definitions includes three sectors of questionable homogeneity—steel, power, and petroleum all aggregated over regions. INTERCOM, on the other hand, is a multi-regional multi-period model of power plants and transmission lines. Thus, it overlaps with ENERGETICOS. CHAC is a partial agricultural sector model that is regionalized for production but aggregated for consumption, with regional price differentials used to compensate for aggregation of consumption.

Because of non-homogenous model structures, it was difficult to link the sub-models with the total economy model. Essentially, the sector models DINAMICO, ENERGETICOS, INTERCOM, and CHAC, represent independent development efforts and their linkages are basically ad hoc.

Now the question arises: what is a consistent multi-level planning model? Or perhaps one should ask, is a multi-level planning model needed?

On the latter, we need to answer the question: are economic variables (including decision units) interdependent? (We are referring here to the most basic or fundamental unit). By interdependent we mean that a change in the state of one leads to a change in the state of the other.
This influence may be just one way or both ways and it may be imperceptible unless sets of variables act in unison. Thus, one manufacturer may increase his output by 10 percent and only minutely affect prices. If one hundred manufacturers do the same, prices could decline sharply resulting in a cut-back in production of all producers. Thus all these manufacturers are interdependent. How should they be represented in a planning model? Ideally, they should be represented individually. With the given state of the arts that is impossible. Thus, to be represented in a planning model they must be aggregated. If they are relatively homogenous units, using the same processes or reacting in a set pattern with respect to each other, no great misinformation likely will be derived. But this is usually not the case. Thus the result is aggregation bias. The alternative then is to work with a hierarchy of models, especially if judgements on decisions at the sector or project level are to be made. But also when it is necessary to investigate alternation techniques or processes of production, these cannot be analyzed at an aggregated level where the real micro choices are not observed, unless pure micro aggregates are involved.

It is this writer's opinion that the ideal multi-level planning model has a consistent structure. This means that each is an aggregate or a disaggregate of the other, partially or totally. Moreover, it means that methods or rules exist for linking them together and that they have exactly the same objective functions.

This ideal was not achieved in the Mexico study and the authors are (were) fully aware of this and if they were to do the study over again they would most likely do it differently. This latter point is speculative since there is no chapter dealing with the limitations of the study. The
reason for the lack of compatibility in the several models is probably because the study represents (1) a first attempt to do such an analysis and (2) sectoral studies were done at different times by more or less independent individuals or groups, as noted before.

Even though a planning model may be consistent, it may be less than ideal, this is, within the economic environment of the country, the results cannot be used for effective planning. As pointed out in the introduction, it should be possible through proper manipulation of the instrument variables to achieve the desired goals.

The builders of these models, at least the central or total economy model, do not look on their modelling in this light. On page 109, it is stated, "This is a model for indicative--not imperative--planning. The model does not include the complexities of collective choice, of multi-person organization and of the incentives for implementation. The structure is a deterministic one--linear programming."

But then in the following paragraph it is stated, "Among the policy issues which can be examined through DINAMICO are: near-future versus distant future increases in aggregate consumption; alternative time paths for dependence upon foreign capital inflows; and the income distribution effects of increasing labor's productivity within the agricultural sector." These statements seem to imply that while certain policy issues can be investigated they cannot be implemented. But this is a contradiction. If some action cannot be taken, then how can it be a policy issue. Instead of policy issues it would be better to call them hypothetical alternatives. In essence they are implementatable in the model but not in the real world.
There is further discussion of the role of CHAC in decision-making, page 473: Here too it is not clear to this writer how certain policies suggested by the model might be economically desirable. For example, it is said in effect that the model is correct in reporting that sugar cane production in the central plateau should be shifted to the tropical zone. But it is not said how this shift will come about, other than saying it would require a shift in processing facilities. Presumably the capital investment for the shift in processing facilities was included in the programming analysis. But, the discussion on page 321 does not indicate this was the case. Moreover, government processing facility investment has not been a policy instrument according to a statement on page 465 where it is said, "Apart from Agrarian Reform, which has been a continuing element of agricultural policy since 1916, investment in irrigation facilities and agriculture research extension have been the major instrument of long-run policy." Guaranteed price support and agricultural production insurance have also been policies of the government, as noted on page 467.

All of this is not to depreciate the work summarized in this book. While it may not be possible to go directly from analysis results to an implementable policy action, the results even though indicative can be useful in preventing the wrong kinds of actions from being taken, like preventing further investment in sugar production in the central plateau or preventing programs from being established when they would not likely achieve their desired goals—like the case of import substitution for agricultural products. But these types of uses are not the most effective way to employ such models, the best way is for the policy instruments to be explicit and direct. Only in this case can the models be adequately tested.
Finally, then, the models constructed for Mexico are very complex and highly innovative. It may be fair to say that these are first generation models of this type and basically methodological. It is best to view them in this way and look forward to second generation improvements.

VI. MULTI-LEVEL PROGRAMMING STUDIES IN THE IVORY COAST

This study has much in common with the multi-level planning study of Mexico. It is in fact the sequel to the Mexico study. There are two distinct differences, however: (1) the Ivory Coast study is more aggregative and (2) part of the analysis is dynamic (that is, the analysis takes place over time). The analysis is Hicksian-dynamic--i.e., it assumes that all values over the planning horizon are known at the initial period. But because of the size of the economy, analysis is done only for five-year intervals between 1970 and 1990. Moreover, because of the well-known problem of cannibalization of capital stock in such models, certain gross capital stock conditions are specified for beyond 1990.

Objectives

The following quote from Chapter 1 (page 11), essentially summarizes the objectives of the study: "One of the main purposes of the model is, indeed, to assess the implications of different objectives and to measure trade-offs between conflicting objectives. The preferred set of objectives has been selected by trial and error." This statement can be interpreted to mean that the goal is to construct and implement a model that will provide the policy-makers (government officials) with good estimates of the consequences of different sets of policy; for example, tariffs, taxes, development projects, and so forth. This is an ambitious objective, to say the least,
but no less ambitious than that for studies reviewed heretofore. The interesting thing is how the analysts go about achieving these objectives.

Methodology

The basic methodology is multi-level planning. The system of analysis includes a highly aggregated macro model, called the Central Model. This Central Model is linked in some degree with sectoral, regional and project models, similar to the system employed for Mexico. Consistent solutions are obtained as for the previous study by an iterative procedure which feeds information back and forth between all levels of aggregates until common variables at the various levels of aggregation converge. Following is a brief description of the models at each level of aggregation.

The Central Model. The sub-sectors included in this model are:

1. Rural, including specific rural projects;
2. Urban, including an iron mine and a Riviera tourism project;
3. Education;

A number of specific activities related to trade, investment and consumption are included in the National Activities subsector. Trade includes activities for import and export of commodities, manufactured goods and expatriate labor and foreign finance. Investments relate to general infrastructure, including roads, schools, water supply, etc., and industrial development. Industrial activities represent eight types of consumer goods. The consumer goods, through utility functions, provide the engine of the models because utility is maximized over the planning period.

Considerable emphasis is placed on the educational sector in the central model because the government desires to replace expatriate workers with Ivorians. The urban and educational sectors are fully integrated into the Central Model but the agricultural sector is not. This means that the
Central Model takes agriculture production and resource use as given—exogenous. However, the urban and educational sectors are fully integrated through aggregate variables which are endogenous.

The solution to the Central Model as well as to all other sector and subsector models is obtained by optimizing linear programming methods. Non-linear variables in the objective function are handled by linear approximations. These non-linear variables include wages and consumption. The value used to weight consumption is not price but utility as measured by iso-elastic utility functions. These utility functions depend only on the level of consumption. The central model includes utility functions for eight types of aggregate consumption.

The Agricultural Sector Model. The agricultural model is regionalized for crops—North and South—and has a separate subsector for livestock. The livestock and crop sectors are linked together by (are competitive through) land, labor and animal power resources. The North and South regional crop subsectors are linked by the exchange of food-stuff and labor. Essentially what this means is that the North furnishes the South with foodstuffs and labor. Most of the demand for food and export industries are located in the South.

Supporting the general agricultural sector model are several detailed sub-models including a dynamic colonization model for the South, cotton modernization and ranch development projects for the North. The full agricultural model consists of 2,822 rows and 4,608 columns.

A number of alternative simulations or sensitivity analyses were done. It was not possible, as noted above, however, to fully integrate the agriculture sector model into this Central Model. Consequently, output and
and the resource use become exogenous data in the Central Model. This is to say, the agricultural output and resources that are generated by the separate agricultural sector model when it uses shadow prices of products and resources that were generated by a previous run of the central model. The Central Model at this stage will likely produce a different set of shadow prices to be used in the separate agricultural model. If the models were fully linked, continued iterations would be done until the \textit{ex ante} and \textit{ex post} shadow prices were the same.

\textbf{The Urban Sector Model.} The core of the urban model is a Leontief input/output matrix which includes 72 unique activities. This matrix is tied to a resource matrix which includes 8 worker skills, 3 types of capital, 2 export groups, 3 import groups and 2 types of public funds. In order to test the efficiency of three alternative technologies a matrix is constructed to represent each. The model also includes 18 final demand categories, 5 for domestic consumption, 2 for government, 3 for investment, 5 for trade, 1 for traditional commerce and 2 for private consumption by foreigners.

When incorporated in the central model, the number of activities is reduced to 57 for each year and makes up largest part of the central model. How this aggregation takes place is not explained.

\textbf{The Educational Model.} The education sector model is quite complex but completely deterministic---i.e., there are no behavioral relations. The model simply projects the demand for certain types of training, i.e., labor skills---given growth in other sectors---and computes the cost of providing this training. The number of students trained is based on the number of students available for training, which is a function of population growth.
The Educational Model projects data for each year while the Central Model, as noted before, makes estimates for every fifth year. Consequently, integration of the Educational Model with the Central Model requires both time and activity aggregations. These aggregations, according to the authors, presented some difficult problems. The aggregated version of the Educational Model has identical educational constraints to those of the Central Model. These are (1) the manpower requirements by various skills and (2) the professional training which leads to a skill category. Fourteen activities provide technological choices for the supply of these skills categories. As noted before, skilled and unskilled workers can be obtained from abroad by activities in the Central Model.

**General Results**

Because of the organization of the report, it is difficult to describe the results, especially for the sector models. Most of the chapters on sectors relate to methodology, not to results. Therefore, in this section more attention is given over-all results than for the Mexican study. The main results are reported in four separate chapters: (1) the free market solution, (2) returns to labor, (3) foreign exchange and savings, and (4) policy experiments. In the free market solution, total utility is maximized given (i) the initial resource conditions, (ii) estimates of the level of the endogenous data which include primary resources, technology, foreign sectors, demand parameters, (iii) demand by the public sector, and (iv) terminal capital levels.

All the data for these solution results relate to national income aggregates and include public and private consumption, investment, savings, merchandise trade net, capital inflow and employment, including the hiring of expatriates.
General conclusions of the analysis for 1970 through 1990 are:

(1) GNP can be expected to grow slightly better than 7%;

(2) the growth in human investment (education) would average 8%;

(3) no net capital inflow would not be needed after 1980;

(4) growth in domestic savings would average just under 8% per year;

(5) growth in foreign trade would decline to about 5% in 1980, then pick up again to about 7% per year by 1990;

(6) The expatriate wage bill would decline to almost zero by 1990.

The authors sum up this outlook as providing a rosy picture for Ivorian development in the future. This development would result in 41% growth in per capita consumption levels between 1970 and 1990 - or at a rate of about 1.7% per year - a very commendable rate of increase.

The distribution of returns to labor and capital change over time under the free market solution, a non-surprising result perhaps. But this result depend on the terms of trade or price relationships.

**Return to Labor.** The model considers 11 types of labor skills, each with its own productivity and supply. Consequently there can be 11 individual wage rates.

In the free market solution, as just noted, all expatriate labor is eliminated by 1990. This is a very profitable type of input substitution because in 1980 the shadow price of the average expatriate is 34 times as high as that of the unskilled urban worker. It must be remembered that this labor substitution is facilitated through expanding the educational system and the number of students trained because large numbers of graduates
are needed to replace expatriates in the earlier years. If the substitution is to take place at a reasonable rate, it is difficult to develop a program that does not create excess capacity and too many graduates by the end of the period. Consequently the analysis shows that by placing a constraint on the training of students in the middle period, a smoother pattern of training over time is possible with little loss in income over the planning period.

While the per capita incomes, on the average, rise over the planning period, the earnings (efficiency wages) of all types of wage earners do not. The wages of unskilled rural workers, the lowest on the wage totem pole, would rise 8% between 1975 and 1985. However, wages for unskilled workers, specialized workers, and clerks would decline by 12%, 7% and 7%, respectively. On the other hand, wages of professionals with M.A. degrees or better increased 26%. The returns to all types of capital would increase under the free market solution.

One may wonder whether the income implications of the numbers would be consistent with general policy. But it must be remembered that the earnings of resources in the model are functions of the amounts available, their productivities and the amounts demanded, all of which result from decisions on the part of the analyst which are required in constructing the model.

**Foreign Exchange and Savings.** Results for foreign exchange and savings are presented in the same chapter although the generic relationship is not apparent. Two alternative solutions are presented for foreign exchange relationships. One was the result of imposing a tariff and the other was the free trade solution. Unfortunately, this reviewer did not find any place in the report a statement of what the tariffs were. Be that as it may, the
imposition of an import tax (tariff) affects not only output and trade, but also the value of resources. Briefly, the value of both exports and imports increase but competing or taxed imports increased the most. Moreover, the shadow-price of foreign exchange and all basic resources values increase as well. This result supports conventional free trade theory.

Two experiments are done with savings. These are called the "open and closed savings loops." The open savings loop is a function of the time rate of discount. In the closed loop an institutional savings constraint is introduced. Experiments are conducted with the open loop by varying the time discount rate and in the closed loop by changing the forced level of public savings which is implemented by changing the tax rate. In the open loop experiment, the rate of time discount is progressively raised from four to seven and then to fourteen percent per year. On the other hand, in the closed loop experiment, the savings rate constraint is increased from none to light and then to high. The optimum or unconstrained solution is achieved by taxation rate of 12.9 percent. The high savings constraint relates to a tax rate of 11 percent and the low rate corresponds to a tax rate of 9 percent.

Each of these experiments results in similar consequences in terms of GNP growth and resource earnings. Average growth in GNP declines from 6.4 percent to 5.6 percent as the time discount rate is raised from 4 to 11 percent. Similarly, the GNP declines from a growth rate of 6.7 percent per year with no savings constraint to 6.2 percent at the high savings constraint (low taxation).
Policy Experiments. The free market solution according to the author "leads to a very rosy picture in terms of aggregate growth." It nevertheless raised a number of problems: depopulation of the north, disguised urban unemployment, high urban housing cost, growing foreign claims on domestic resource and increasing income disparities. It is of interest therefore to derive the implications of alternative policy implements. The following policy instruments were tried as a means of eliminating these so-called undesirable economic effects:

1. A tariff on imports;
2. quotas on foreign labor;
3. quotas on foreign capital;
4. approval of an enclave iron ore project;
5. higher taxes on public savings;
6. a development program for agriculture in the north;
7. excise taxes and subsidies;
8. a definite school enrollment policy.

None of these policy instruments produced a satisfactory employment level. The removal of tariffs on manufactured imports resulted in a transfer of income from the urban to the rural population. Also, imposing a quota on foreign labor did not solve the unemployment problem. This result may be due to the type of production techniques considered in the model.

Removal of tariffs on imports increased GNP and the social welfare index, but it also resulted in a shift of income from the urban to the rural sector, which might be viewed as a good result, at least by the rural people.
The quota on foreign capital "is not a good solution," it is said, because it reduces income growth. Moreover, it penalizes the lower income groups more than the higher income groups. This resulted because the higher income groups receive greater rents from their resources of both skilled labor and capital as a result of less than optimum capital stock.

A very interesting result is forthcoming when a rural development program is instituted in the north. This analysis takes place through an interaction of the agriculture sector model and the central model. The development program consists mainly of public investments and subsidies plus compulsory government production quotas for farmers. How these programs would be implemented in practice is not detailed. In any case, the results are: employment is increased by 150% in the north by 1990, investments are increased by 320%; public subsidies by 370%—all compared with the free market solution. These results are achieved, if strong tax and public savings programs are followed, with only a .9% decline in total welfare over the planning period—1970 to 1990.

For the agricultural sector two alternative analysis results are presented out of several done. These are called "free" and "forced." The free alternative maximizes returns to rural resources given certain resource values from the Central Model. The "forced" solution imposes a maximum of bounds for commodity production which limits the domain for maximization of returns to rural resources. Over the analysis horizon 1970 through 1985 the growth of output, non-rural resource use, rural resource use, agricultural value added, all are higher under the forced solution. However, returns to land are less because the increased level of output results in lower prices which yield lower returns to land and other rural resources, although
the latter values are given in the report. All this is to say that from the point of view of the sector, the forced solution is uneconomic and if the resource values and product prices are correctly shadow priced, the forced solution is uneconomic from the point of view of the economy. It is worth noting, too, that under the free solution "modern" types of production techniques are not selected because it is more profitable to use labor intensive and purchased resource saving techniques. This writer thinks that the author(s) errs when he states, "Therefore (because of the non-adoption of modern techniques in the free solution) a new step forward in applied research is needed, especially for foodstuffs, to allow modernization to be more profitable and to be adopted by decision-makers in the rural sector" (Chapter 17, page 26). There is no guarantee that new research is going to make new methods more profitable than those which already exist, especially if the research cost is taken into account. Moreover, "modern" is a value-judgment word. Such words should not be involved in the determination of the best resource allocation.

The forced rural solution also has a negative impact on the total GDP growth, which is 6% compared with 6.7% under the free solution. Other items such as the foreign trade surplus and the budget surplus also are negatively affected.

Several experiments were made with resource allocation and project appraisals. The main experiment for resource allocation dealt with employment. Under the two alternatives, free and forced, there is a significant seasonal pattern of labor requirements, even with the more advanced technology required under the forced alternative. In both the North and South, labor surpluses and deficits occur seasonally. However, they do not always
occur during the same season; hence, seasonal labor migration could help solve regional labor shortages. Moreover, it is suggested that surplus urban labor could be used to harvest coffee and cocoa.

The experiment with the project appraisals analyzes a project for modernization of cotton production. In this analysis, net income per hectare is greatest with the technique that uses oxen, second highest with improved techniques (mainly biological) and least with the technique that uses tractor power. It is explained that the tractor power technique is not profitable because it is not possible to use tractors at their full capacity.

These are just some of the highlights of the total analysis, which are presented only to indicate some of the possibilities that are available and the scope of the analysis.

Evaluation

The results just summarized certainly meet the criterion of reasonableness. From what is presented in the report, the methodology appears to be very imaginative in its means of looking at the total economic scene within years and between years and the innovative way that the educational sector is included in the analysis, even though the educational sector is deterministic. The urban sector is essentially a Leontief input/output model but allows for some technological change by specifying three alternative matrices. Solutions to these matrices are then passed up to the central optimizing model for selecting the best or most appropriate set in aggregative terms. The agriculture sector model, on the other hand, is an optimizing model in which product prices and resource costs are those given by the central model. It then provides the central model with resource use and output in the
agricultural sector. Thus, the prices used in the sector model and the central model are not necessarily consistent. There is no attempt in the report to analyze any or compare possible inconsistencies.

But more importantly, nowhere are there presented any results related to the validation of the model. Presumably no validations were done. One certainly would have more confidence in the results if the authors had shown how well or how poorly the model replicated the past, given the values of the exogenous variables. Until analyses follow such a procedure, would-be users and potential practitioners are going to be skeptical of the methodology. Apparently time did not permit such luxury on the part of the analysts or the results were poor, and consequently, none are presented for the reader's evaluation.
Bibliography


(10) Korean Agricultural Sector Study.

   The National Agricultural Cooperative Federation: An Appraisal

   Rural Infrastructure (Special Report No. 2), 1972, 83 pp. -
   Sang Gee Kim and L. W. Libby

   An Analysis of New Land Development in Korea (Special Report

   Population, Migration, and Agricultural Labor Supply (Special

   Organization and Performance of the Agricultural Marketing System
   in Korea (Special Report No. 7), 1972, 105 pp. - Sang Kuk Han,
   et al.

   Crop Production Data and Relationships (Special Report No. 8),

   User's Manual for the Korean Agricultural Simulation Model
   (Special Report No. 9), 1973, 5 Chapters, 6 Appendices -
   Thos. J. Manetsch and Tom W. Carroll.

   A Macro Model of Economic Growth and Income Distribution:
   An Application of Systems Simulation to the Korean Case
   (Special Report No. 10), 1972 - Ho Tak Kim

       Joint publications of the Agricultural Economics
       Research Institute, Ministry of Agriculture and
       Forestry, Republic of Korea; and the Department
       of Agricultural Economics, Michigan State University
       East Lansing, Michigan.

(11) Lin, W., G.W. Dean and C.V. Moore, "An Empirical Test of Utility

(12) Little, I. M. D. Project Appraisal and Planning and for Developing
     Countries, by I. M. D. Little and J. A. Mirrlees. London,

(13) McMahon, C. W. Techniques of Economic Forecasting. Paris, OECD,

(14) Robbins, Lionel. An Essay on the Nature and Significance of
     revised and extended), 160 pp.


<table>
<thead>
<tr>
<th>No.</th>
<th>TITLE OF PAPER</th>
<th>AUTHOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>265</td>
<td>India's Population Policy: History and Future</td>
<td>R. Gulhati</td>
</tr>
<tr>
<td>266</td>
<td>Radio for Education and Development: Case Studies (Vols. I &amp; II)</td>
<td>P. Spain, D. Jamison</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E. McAnany</td>
</tr>
<tr>
<td>267</td>
<td>Food Insecurity: Magnitude and Remedies</td>
<td>S. Reutlinger</td>
</tr>
<tr>
<td>268</td>
<td>Basic Education and Income Inequality in Brazil: The Long-Term View</td>
<td>J. Jallade</td>
</tr>
<tr>
<td>269</td>
<td>A Planning Study of the Fertilizer Sector in Egypt</td>
<td>A. Choksi, A Meeraus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A. Stoutjesdijk</td>
</tr>
<tr>
<td>270</td>
<td>Economic Fluctuations and Speed of Urbanization: A Case Study of Korea 1955-1975</td>
<td>B. Renaud</td>
</tr>
<tr>
<td>271</td>
<td>The Nutritional and Economic Implications of Ascaris Infection in Kenya</td>
<td>L. Latham, N. Latham</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. Basta</td>
</tr>
<tr>
<td>272</td>
<td>A System of Monitoring and Evaluation of Agricultural Projects</td>
<td>M. Cernea, B. Tepping</td>
</tr>
<tr>
<td>273</td>
<td>The Measurement of Poverty Across Space: The Case of Peru</td>
<td>V. Thomas</td>
</tr>
<tr>
<td>274</td>
<td>Economic Growth, Foreign Loans and Debt Servicing Capacity of Developing Countries</td>
<td>G. Feder</td>
</tr>
<tr>
<td>275</td>
<td>Land Reform in Latin America: Bolivia, Chile, Mexico, Peru and Venezuela</td>
<td>S. Eckstein, G. Donald</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D. Horton, T. Carrol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(consultants)</td>
</tr>
<tr>
<td>276</td>
<td>A Model of Agricultural Production and Trade in Central America</td>
<td>R. Norton.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. Cappi, L. Fletcher,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. Pomareda, M. Wainer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(consultants)</td>
</tr>
<tr>
<td>277</td>
<td>The Impact of Agricultural Price Policies on Demand and Supply, Incomes and Imports: An Experimental Model for South Asia</td>
<td>M. Osterrieth, E. Verrydt, J. Waelbroeck</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(consultants)</td>
</tr>
<tr>
<td>278</td>
<td>Labor Market Segmentation and the Determination of Earnings: A case Study</td>
<td>D. Mazumdar</td>
</tr>
<tr>
<td>279</td>
<td>India - Occasional Papers</td>
<td>M. Ahmed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M. Ahluwalia, J. Wall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. Reutlinger, M. Wolf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R. Cassen (consultant)</td>
</tr>
<tr>
<td>No.</td>
<td>TITLE OF PAPER</td>
<td>AUTHOR</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>280</td>
<td>Educational Effects of Class Size</td>
<td>W.D. Haddad</td>
</tr>
<tr>
<td>281</td>
<td>Relieving Traffic Congestion: The Singapore Area License Scheme</td>
<td>P.L. Watson, E.P. Holland</td>
</tr>
<tr>
<td>282</td>
<td>World Trade and the International Economy: Trends, Prospects and Policies</td>
<td>B. Balassa</td>
</tr>
<tr>
<td>284</td>
<td>Pakistan: Forestry Sector Survey</td>
<td>S.A. Draper, A.J. Ewing, J. Burley, G. Grayum (consultants)</td>
</tr>
<tr>
<td>285</td>
<td>The Leisure Cost of Electric Power Failures</td>
<td>M. Munasinghe</td>
</tr>
<tr>
<td>286</td>
<td>Shadow Pricing and Power Tariff Policy</td>
<td>M. Munasinghe, J. Warford</td>
</tr>
<tr>
<td>287</td>
<td>Wages, Capital Rental Values and Relative Factor Prices in Pakistan</td>
<td>S. Guisinger (consultant)</td>
</tr>
<tr>
<td>288</td>
<td>Educational Reform in the Soviet Union: Implications for Developing Countries</td>
<td>I. Blumenthal, C. Benson (consultants)</td>
</tr>
<tr>
<td>289</td>
<td>Petroleum and Gas in Non-OPEC Developing Countries: 1976-1985</td>
<td>R. Vedavalli</td>
</tr>
<tr>
<td>290</td>
<td>Major Reforms of the Swedish Education System</td>
<td>A. Heidenheimer (consultant)</td>
</tr>
<tr>
<td>291</td>
<td>Industrialization, Technology and Employment - China</td>
<td>T.G. Rawski (consultant)</td>
</tr>
<tr>
<td>292</td>
<td>Development and Income Distribution - Zambia</td>
<td>C. Blitzer</td>
</tr>
<tr>
<td>293</td>
<td>World Potash Survey</td>
<td>W.F. Sheldrick, H. Stier</td>
</tr>
<tr>
<td>294</td>
<td>The Economic Dimensions of Malnutrition in Young Children</td>
<td>M. Selowsky</td>
</tr>
<tr>
<td>295</td>
<td>The Technology of Rural Development</td>
<td>J.P. McInerney (consultant)</td>
</tr>
<tr>
<td>296</td>
<td>The Financial Cost of Agricultural Credit: A Case Study of Indian Experience</td>
<td>C.D. Datey (consultant)</td>
</tr>
</tbody>
</table>
Egbert, Alvin Charles. Agricultural sector planning models: a selected summary and critique /