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MICRO-COMPUTERS AND AGRICULTURAL POLICY MODELING: A FEASIBILITY STUDY

by

R.C. Kite
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INTRODUCTION

As the first stage in the project to investigate the potential of microcomputers in applications of economic frameworks for agricultural policy analysis, a review of various policy modeling systems has been undertaken. This is a preliminary report on the kinds of systems used and the types of policy analyses undertaken with those systems.

At this stage, the various models or systems will not be 'evaluated' with an intent of determining their strengths or weaknesses with respect to applications of economic theory or (if applicable) statistical or mathematical method. However, since the goal of this activity is to determine potential for applications on the relatively limited resources of the micro-computer, some obvious judgements with respect to size and technique are relevant. These judgments are reflected by the scheme used to classify the various analytic systems.

A DESCRIPTIVE FRAMEWORK

A system of classification which will be useful for determining a particular model's micro-adaptability falls directly from a review of modeling systems applied to developing nations. These applications generally have five characteristics:

SYSTEM: Simulation, Optimization or Descriptive

MODEL: General or Partial Equilibrium

SPECIFICATION: Behavioral or Consistency

STRUCTURE: Simultaneous or Recursive

TIME: Dynamic or Static

PARAMETERS: Experimental
Econometric
Input/Output
Stylized

Before defining what each category is meant to encompass, and its relevance to the work at hand, we should note that the elements of each of the five characteristics are not mutually exclusive. There are some systems, for example, which include both simulation and optimization components, particularly for some of the partial equilibrium models, and for some general equilibrium models which incorporate a large amount of sectoral detail in a basic general model. Although we might expect that

such systems are beyond the limited resources of a micro-computer, they are frequently recursive and as such are legitimate candidates for this investigation.

SYSTEMS

Three types of overall **SYSTEMS** are frequently employed in constructing policy evaluation tools. They are SIMULATION, OPTIMIZATION, and DESCRIPTIVE Systems.

Simulation systems will be defined as those which have no overall optimization rule. (The specification of these systems may include assumptions about optimizing behavior on the part of economic agents.)

Optimization systems - usually mathematical programming constructs - are self-defining in that there will exist a rule determining the admisability of a particular solution. We would, therefore, include under this classification applications of control theory since these applications are guided by an overall objective function.

Descriptive systems are also self-defining. They are characterized by the absence of formal specification and generally concentrate on what will occur (or has occured) from a qualitative point of view. Although many of these applications have a great deal of merit, they are dependent on special knowledge and experience and are not suceptable to treatment as defined in this investigation. (This particular element of the policy evaluation process is crucial to the more formal applications considered here, since it must proceed the formalization of a particular model, and must be an element of the evaluation and interpretation of the output generated by the more formal models.)

MODELS

Two general kinds of **MODELS** are identified: GENERAL and PARTIAL EQUILIBRIUM models.

General equilibrium models will usually be multi-sectoral representations which aim to portray an entire economy. Both of what we have called Simulation and Optimization systems may be general equilibrium models but the majority of them are Simulation systems and are therefore especially micro-adaptable.

Partial equilibrium models dominate policy modeling (by count) and are usually sector or commodity specific. These applications have provided a wide range of experience in the use of the various Systems, Specifications, Structures and Time characteristics and may vary anywhere between one and thousands of formal relationships. Because of the wealth of applications of these models, some are obviously micro-adaptable and some are not. We are interested in all of them, however, with respect to both Structure and Specification.

SPECIFICATION

Two general types of **SPECIFICATION** and two types of **STRUCTURE** are used by policy system builders. These are **Behavioral** or **Consistency** Specification and **Simultaneous** or **Recursive** Structure. Both of these classifications are important from the point of view of micro-adaptability because they determine the demands on computational resources. Both are important from an analytic point of view as well, because they reflect on the credibility of the system and lead directly to questions about data requirements and technique. (Technique, that is the manner in which the parameters are obtained, is not a direct concern of this investigation. But, the interaction between model specification and structure, as it relates to technique, will obviously influence any eventual adaption or application of a micro-implimented policy evaluation tool.)

By **Behavioral Specification** we mean that relationships are derived from an explicit economic theory, incorporating relevant restrictions and, where appropriate, functional forms. The specific theory may be any one of several (Classical, Neo-classical, Keysaian, Supply-side or Structuralist). We require only that the theory be explicit.

A **Consistency Specification** is done primairly via identities or quasi-identities. We might call such models 'accounting' models in the sense that they impose the necessary balances without attempting to explain how the various components adapt to stimuli. Input/output models, the related Social Accounting Matrix approach, and systems which extrapolate by trends or fixed growth rates what would otherwise be behavioral variables will fall under this cla sification. There is a uni-directional link (if one exists between behavioral and consistency specifications in that a behavioral specification may be converted to a consistency form -- the inverse will seldom be true. Consistency models, because of their nature, are especially micro-adaptable (but of limited use for policy work). They are usually recursive (the exception being Input/output and SAM models) in that they rely so heavily on predetermined input.

STRUCTURE

The **Structure** of a model centers around 'feedback' allowed by the specification. Specification also determines wether or not the model time frame is **Static** or **Dynamic**. Like the other components of this classification scheme, there can be different combinations of structure and time dimensions. The meanings of the **Simultaneous** and **Recursive** structures are straightforward:

<u>Simultaneous</u>: $Y = f(X,Z)$
$X = f(Y,Z)$, where Y and X are mutually dependent;

<u>Recursive</u>: $Y = f(Z)$
$X = f(Y,Z)$, where Y is independent of X.

These, of course, may extend to block recursive systems with each block consisting of several sets of simultaneous relationships. Large systems with block resursive structures will be especially suitable for adaptation to the micro-computer.

TIME

An additional dimension, **TIME**, of the classification scheme will also affect the adaptability of a model. Like the question of the simultaneity or recursiveness of a model, a **Static** or a **Dynamic** model will be more or less micro-adaptable. Although it may sometimes be more complicated than this, we will define a model as **Dynamic** if it contains explicit links between time periods, with the additional requirement that the system, in moving from period "t" to "t + n", pass through the interviening periods. By exclusion, a **Static** model will be one which represents the economic system at specific points.

PARAMETERS

The final element of the classification scheme, **PARAMETERS**, refers to the source of the parametric input to the system. There are four broad categories under this classification:

Stylized parameters are input generally <u>believed</u> to represent the system being analysed. This includes trends, averages and experiments with general models using assumed response parameters.

Econometric - meaning the use of statistical methods to obtain response parameters. The fitted functions may or may not be derived from an underlying theory.

Experimental - derived from planned experiments such as field trials.

Input/output - generally refering to Leontief type models.

A particular system, particularly the larger, more complete models, may include parameters derived from each of these sources. As mentioned earlier, this aspect of a system is not the immediate concern of this investigation. However, demands in terms of the number and kinds of parameters required by a System will be an important consideration when we begin to consider a proto-type system.

APPLICATIONS OF POLICY ANALYSIS SYSTEMS

An exhaustive survey of policy modeling systems has not been undertaken. Where and when possible existing surveys have been used to obtain information about model structures and applications. Among the works which have been particularly useful are: Taylor(1983), Dervis et al(1982), Kutcher and Norton(1982), Thorbecke and Hall(1982), Hazell(1982), Taylor et al(1980), McCarl and Spreen(1980), Taylor(1979), and Manne(1974). Each of these has extensive references to applications or theory across a broad range of policy or sector analyses. Examples of the various Systems developed and/or applied to developing nations have been extracted from these and other publications. Several examples of the various applications are presented according to the Descriptive Framework. These examples are intended to show the general characteristics of the various Systems. We expect, from this information, to develop the requirements for a general analytic framework which can be applied to Agricultural Policy questions.

OPTIMIZATION SYSTEMS: GENERAL EQUILIBRIUM MODELS

Since the General Equilibrium Optimization System will usually require computational resources in excess of those available on a micro-computer, we will deal only briefly with the structure and application of such systems. There is a discussion of such systems in Chapter 3 of Dervis et al(1982). Figure 1 has been taken from that discussion as a demonstration of a dynamic general equilibrium linear programming model. The entire tableau constitutes the dynamic model. The upper left-hand block in the figure may be considered the static form of the model.

Although they are not constructed precisely like the tableau shown in Figure 1, similar systems have been constructed for a variety of countries. Manne(1974) reports 18 such systems, ranging from a static model of Hungary with 491 input/output sectors to a dynamic (optimal control) model of Korea having 30 time periods and four sectors. A common characteristic of these systems is the input/output matrix (shown in Figure 1 in the upper left-hand corner).

In principle, there is no reason why such models cannot (in a scaled-down version) be implimented on a micro-computer -- especially assisted by matrix generators and report writers. Remembering that the critical computational constraint is the number of rows in the tableau, and that one may choose to optimize on any of the activities these models provide a reasonable amount of flexibility for analysing exchange rate, investment, pricing policy, import and export restrictions, resource constraints, and production technologies.

These systems are subject to the usual criticism of the linearity involved and the lack of 'feed-back' between implicit prices (shadow prices) and the parametric prices.

Figure 1.
A Dynamic Linear Programming Tableau

	X_1	Y_1	M_1	E_1	C_1	X_2	Y_2	M_2	E_2	C_2	K_2	X_3	Y_3	M_3	E_3	C_3	K_3	K_4		
MBAL1	$-(I-A)$	S	$-I^m$	$+I^m$	Q_1														$\leq$	P_1
CAP1	$\hat{K}$																		$\leq \bar{K}_1$	RN_1
INV1		$-I$																	$\leq (I-\hat{DP})\bar{K}_1$	U_1
LAB1	L_1^s										$+I$								$\leq \bar{L}_1$	W_1
BOP1		$PW_1\hat{S}_1$	PW_1	$-PW_1$															$\leq \bar{F}_1$	SR_1
MBAL2						$-(I-A)$	S	$-I^m$	$+I^m$	Q_2									$\leq$	P_2
CAP2						$\hat{K}$					$-I$								$\leq$	RN_2
INV2							$-I$				$-(I-\hat{DP})$						$+I$		$\leq$	U_2
LAB2						L_2^s													$\leq \bar{L}_2$	W_2
BOP2							$PW_2\hat{S}_2$	PW_2	$-PW_2$										$\leq \bar{F}_2$	SR_2
MBAL3												$-(I-A)$	S	$-I^m$	$+I^m$	Q_3			$\leq$	P_3
CAP3												$\hat{K}$					$-I$		$\leq$	RN_3
INV3													$-I$				$-(I-\hat{DP})$	$+I$	$\leq$	U_3
LAB3													L_3^s						$\leq \bar{L}_3$	U_3
BOP3													$PW_3\hat{S}_3$	PW_3	$-PW_3$				$\leq \bar{F}_3$	SR_3
OBJ. FUNC.					$\left(\frac{1}{1+\rho}\right)$					$\left(\frac{1}{1+\rho}\right)^2$						$\left(\frac{1}{1+\rho}\right)^3$		$\bar{U}_4$		

I = identity matrix of order $n \times n$
I^m = identity matrix of order $n_1 \times n_1$ (n_1 = number of tradables)
A = input-output matrix
S = capital composition matrix
$\hat{S}$ = diagonal noncompetitive import requirements matrix
PW_{it} = world price vectors
Q_t = consumption shares vectors
$\hat{K}$ = diagonal matrix of capital-output ratios
$\hat{DP}$ = diagonal matrix of depreciation rates
L_t = labor coefficients matrix
$\bar{U}_{T+1}$ = terminal capital price vector
ρ = social rate of discount

PW_{it} = the dollar prices of competitive imports and exports
PW_{mt} = the dollar price of noncompetitive imports
M_{mt} = noncompetitive imports

$\bar{F}_t$ = net foreign capital inflow expressed in dollars
n_1 = the number of tradable sectors, assumed to be the first n_1 sectors distinguished in the model

As mentioned earlier, it is possible to combine optimization and simulation models to overcome this problem -- but these systems would probably be outside the scope of this effort. Similarly, optimization methods which may be used with non-linear models will usually be outside the bounds imposed by our interest in the micro-computer.

OPTIMIZATION SYSTEMS: PARTIAL EQUILIBRIUM MODELS

Partial equilibrium models easily dominate the field of applied optimizing systems. This does not mean, however, that they are 'smaller' or less complex than the general equilibrium models. The well known CHAC model of Mexico, for example, contains several thousand relationships. Systems similar to CHAC have been developed for several other countries, including Brazil (2300 equations) and Egypt (1000 equations). Obviously, systems such as these are beyond application on a micro-computer. But there are some aspects of their specification which are relevant to smaller constructions which could be applied.

CHAC, besides demonstrating the potential for Agricultural Sector planning models, was probably the first system to incorporate product demand curves directly in the tableau - thus overcomming some of the objections to this kind of system. Besides CHAC, and CHAC-clones, this procedure has been employed in several other partial equilibrium models. One such example is the Dominican Republic Agricultural Sector Model [House and Erickson, 1980]. This model contains over 800 equations and 2000 activities and, again, is not especially micro-adaptable. A diagram of a model which begins to approach the size which could be adapted is shown in Figure 2. This example is taken from the ADAM model of the Philippines [Gonzales, et al, 1982]. This model contains approximately 170 equations and 405 activities.

Figure 2
Tableau for the ADAM Model of the Philippines

| COLUMNS / ROWS | PRODUCTION | | | | | | | | | | | | PROCESSING | | | | TRANSFORMATION | TRANSFER | FEED MIXING | INPUT SUPPLY | | | | | | EXPORT-IMPORT | DEMAND | | | | | | | | | | | |

An example of an even more 'partial' model is shown in Figure 3 [Andrews and Moore, 1976]. This model of the Dominican Republic has 100 equations and 149 activities, so it and similar models could easily be adapted to a micro-computer.

Figure 3
Tableau of a Production/Consumption Farm Model

	17 Production Activities	3 Sets of Family Labor Activities	27 Sales Activities	8 Financial Activities	42 Storage Activities	40 Food Purchasing Activities	Right Hand Side
	$u_1 u_2 \cdots u_{17}$	$v_{1,1} \cdots v_{5,3}$	$w_1 \cdots w_{27}$	$a_1 \cdots a_8$	$x_1 \cdots x_{42}$	$z_1 \cdots z_{40}$	
4 Land Constraints (1)	$\begin{bmatrix} 1 & \cdots & 1 \\ \vdots & & \vdots \\ 1 & \cdots & 1 \end{bmatrix}$						$\begin{matrix} \leq L_1 \\ \vdots \\ \leq L_4 \end{matrix}$
4 Irrigated Land Constraints (2)	$\begin{matrix} 1 \\ \vdots \\ 1 \end{matrix}$						$\begin{matrix} \leq .07L_1 \\ \vdots \\ \leq .07L_4 \end{matrix}$
5 Labor Requirements (3)	$\begin{bmatrix} n_{1,1} & \cdots & n_{1,17} \\ \vdots & & \vdots \\ n_{5,1} & \cdots & n_{5,17} \end{bmatrix}$	$\begin{bmatrix} -1 & -1 & -1 \\ \vdots & \vdots & \vdots \\ -1 & -1 & -1 \end{bmatrix}$					$\left.\right\} \geq 0$
15 Labor Restrictions (4)		$\begin{bmatrix} 1 & & \\ & \ddots & \\ & & 1 \end{bmatrix}$					$\begin{matrix} \leq N_{1,1} \\ \vdots \\ \leq N_{.,5} \end{matrix}$
36 Distribution Equations (7)	$\begin{bmatrix} q_{11} & \cdots & q_{1,17} \\ \vdots & & \vdots \\ q_{36,1} & \cdots & q_{36,17} \end{bmatrix}$		$\begin{bmatrix} -1 & & \\ & \ddots & \\ & & -1 \end{bmatrix}$		$\begin{bmatrix} -1 & & \\ .98 & -1 & \\ & \ddots & \\ & & -1 \end{bmatrix}$		$\left.\right\} \geq 0$
8 Calorie and Prot. Constraints		$\begin{bmatrix} -g_1 & -g_2 & -g_3 \\ \vdots & \vdots & \vdots \\ -g_1 & -g_2 & -g_3 \end{bmatrix}$			$\begin{bmatrix} k_{1,1} & -k_{2,1} & \\ & k_{2,2} & \\ & & \\ & & k_{8,42} \end{bmatrix}$	$\begin{bmatrix} k_{1,1} & \cdots & k_{1,40} \\ \vdots & & \vdots \\ k_{8,1} & \cdots & k_{8,40} \end{bmatrix}$	$\begin{matrix} \geq K_1 \\ \vdots \\ \geq K_8 \end{matrix}$
24 Other Nutrition Constraints					$\begin{bmatrix} o_{1,1} & -o_{2,1} & \\ & o_{2,2} & \\ & & \ddots \\ & & o_{8,42} \end{bmatrix}$	$\begin{bmatrix} o_{1,1} & \cdots & o_{1,40} \\ \vdots & & \vdots \\ o_{24,1} & \cdots & o_{24,40} \end{bmatrix}$	Min. and Max Limits
4 Cash Flow Constraints (5)	$\begin{bmatrix} -c_{1,1} & \cdots & -c_{1,17} \\ \vdots & & \vdots \\ -c_{4,1} & \cdots & -c_{4,17} \end{bmatrix}$		$\begin{bmatrix} p_{1,1} & \cdots & p_{1,27} \\ \vdots & & \vdots \\ p_{4,1} & \cdots & p_{4,27} \end{bmatrix}$	$\begin{bmatrix} +1 & -1 & & +1 \\ & +1 & -1 & -1.05 \\ & & \ddots & \ddots \\ & & +1 & -1.05 \end{bmatrix}$		$\begin{bmatrix} -d_{1,1} & \cdots & -d_{1,40} \\ \vdots & & \vdots \\ -d_{4,1} & \cdots & -d_{4,40} \end{bmatrix}$	$\left.\right\} = 0$

Many of the partial equilibrium models have an additional characteristic that is not apparent from the tableau shown. Although they appear to be static with respect to time, they are what we might call quasi-dynamic because inter-period restrictions must often be set on such inputs as land, labor and water. This makes them especially well suited to policy analyses aimed at farming technology, land policies, nutrition questions, and credit and pricing policies. Some of these systems, notably CHAC, have been used to assist in the development and evaluation of development plans for consistency and feasibility. It is apparent that any general system intended for use as an Agricultural Policy analysis tool must allow for at least mid-size partial equilibrium optimization models.

SIMULATION SYSTEMS: GENERAL EQUILIBRIUM MODELS

Simulation systems will be especialy micro-adaptable but they have the disadvantage that, unless they are parametizied via the 'Stylized' method, they are demanding of lengthy time-series and/or cross-sectional data. In cases where there are sufficient data available (notably the developed countries) numerous general equilibrium models have been developed. Since we are interested in applications to developing countries, these models will not be described, except to note something about their general structure.

One of the reasons these systems are so adaptable is that they are easily broken in segments. The potential for such segmentation is indicated by Figure 4 which shows, in a very aggregate form, the major sectors of a general equilibrium system.

Figure 4
Macro Sectors in A General Equilibrium System

```
                          (Development Goals)
                            --------------
                            | GOVERNMENT |
                            --------------
                                /|\
Technology                     /PRICE\                 Commercial Policy
          \--------------/ INCOMES \ ----------/
           | PRODUCTION |-----|------|  TRADE |
          /--------------\INVESTMENT/----------\
Resources                   \  |   /                 Rest  of  World
                                \| /
                           ---------------
                           | CONSUMPTION |
                           ---------------
                         /       |         \
           Demographics      Health     Nutrition
```

Naturally, each of the macro sectors shown in Figure 4 are broken into separate sectors, such as Agriculture, Manufacturing, Transportation, etc which may themselves be further

disaggregated. The attractiveness of a simulation system is that it, and its solution procedure, can be organized so that considerable disaggregation is possible.

Simulation systems intended to capture the interactions implicit in Figure 4 have been built for virtually all of the developed economies, or geographic aggregations of those nations, as well as for many developing economies. The models may be more or less aggregated, but each follows the broad outline indicated by Figure 4. Where these systems differ is in the specification, structure and time categories. With few exceptions, each can be implemented on a micro-computer.

As a point of departure, Table 1 shows the functions specified for a general equilibrium model [Clements, 1980]. This model contains some, but not all, of the characteristics we should require for use in a developing nation. It has no provision for the government sector, price controls, import or export controls or taxes and subsidies. In addition, investment is determined outside the model. However, it does contain many features which are common to general equilibrium models.

Table 1
A General Equilibrium Simulatiion Model

Consumption

$$C=\sum_{i=1}^{n} p_i T_i - a(W - P_{T_{n+1}}) - I$$

Absorption

$$A = C + I$$

Wealth

$$W = W_{-1} + Y - C$$

Consumer Expenditure System

$$v_i^d = p_i T_i + \theta_i (C - \sum_{j=1}^{n} p_j T_j) \qquad i=1,\dots,n$$

$$\sum_i \theta_i = 1$$

Aggregate Price Index

$$P = \epsilon_i + \sum_{i=1}^{n} \theta_i p_i$$

Total Expenditures

$$v_i = v_i^d + v_i^s \qquad i=1,\dots,n$$

Supply System

$$z_i = \epsilon_{i+1} + \lambda_i \sum_{j=1}^{n} (\phi_{ij}/\phi_{i.} - \phi_{j.})p_j + (\lambda_i/\bar{h})h \qquad i=1,\dots,n$$

$$\Phi = \Phi', f'\Phi f > 0 \text{ for any } f \neq 0$$

where $\Phi = [\phi_{ij}]$, $\phi_{i.} = \sum_j \phi_{ij}$ and $\sum_i \phi_{i.} = 1$

Income

$$Y = \epsilon_{n+1} - \sum_{i=1}^{n} (z_i + \lambda_i p_i) + \Delta D + DS - \bar{W}_{-1}(\Delta P) + (\Delta \bar{P}) W_{-1}$$

Trade Flows

$$\epsilon_{i+n+1} - z_i + \lambda_i p_i - v_i = \begin{cases} \epsilon_i & i \in \psi \\ 0 & i \notin \psi \end{cases}$$

Trade Balance

$$B = \sum_{i \in \psi} \epsilon_i$$

THE ENDOGENOUS VARIABLES

Variable	Description
C	Consumption
A	Absorption
W	Wealth
$v_i^d (i=1,\dots,n)$	Domestic consumption expenditure on commodity i
P	Aggregate price index
$v_i (i=1,\dots,n)$	Total domestic expenditure on commodity i
$z_i (i=1,\dots,n)$	Output of sector i
Y	Income
$\epsilon_i (i \in \psi)$	Value of trade flow in good i
$p_i (i \notin \psi)$	Price of non-traded good i
B	Trade balance

TABLE 3
THE PREDETERMINED VARIABLES

Variable	Description
I	Total domestic investment expenditure
W_{-1}	Lagged wealth
$v_i^s (i=1,\dots,n)$	Domestic investment expenditure on commodity i
h	Aggregate resource endowment
ΔD	Change in domestic credit component of monetary base
DS	Debt service surplus
$p_i (i \in \psi)$	Price of traded good i

First, the consumption component is represented by a Linear Expenditure System (LES). The use of a complete demand system often destinguishes a general model from a partial model.1/ Examples of this type of a specification are found in Dervis, et al(1980) and a model of Egypt [Taylor, 1979]. A somewhat related method is used in a general equilibrium model for India [Yotopoulos and Lau, 1974] which specifically consentrates on the Agricultural Sector. (The Yotopoulos and Lau model contains a additional feature in that the farm consumption/labor and production decisions are integrated through utility and profit maximization with the production/consumption components being block recursive. Applications of the LES (or related systems) in partial equilibrium models are especially numerous in food policy work. Examples are:

Venezula, Columbia, Peru, Chile,[Howe,1977];
Brazil, [Gray, 1982];
Malaysia, [Barnum and Squire, 1979];
Korea, [Ahn, et al, 1979];
Indonesia, [Dixon,]; and
Sierra Leone, [Strauss, 1982].

Second, the production subsystem is fully specified, with appropriate restrictiions.2/ Variations on this framework include alternative forms of the production function, input/output systems and constructs to account for factor distortions caused by various policies. Two models, one of Japan [Mundlak, 1979] and one for Argentina [Cavallo and Mundlak, 1982] have extended the general equilibrium framework to account for migration out of agriculture, credit availability and agricultural investment. An extension which could be, but often isn't, made is to complete the factor demand component. This, in fact is one of the distinguishing differences between the optimizing and the simulation systems, since the optimizing systems are usually concerned with factor restrictions. The behavioral specification of many partial models such as those by Yotopoulos and Lau(1974) have addressed the factor demand component. But these models usually include only aggregate categories of labor, capital and land -- categories which are too broad for meaningful analysis.

Finally, we have the market clearing mechanism. This particular formulation, like many others, separates the economy into three sectors: exportables, importables and non-traded goods. Although it is not explicit in the example, domestic prices for the traded commodities are determined by world prices and the exchange rate. Prices for the non-traded commodities are determined by supply and demand interaction within the domestic economy. A central question about the market clearing mechanism is wether prices or quantities are the appropriate adjusting variables. The Structuralist view [Taylor, 1983] would be that the majority of the adjustment takes place on the quantity side with prices determined by factor costs, markups and taxes or subsidies. In either case, these systems achieve final balance between the investment/savings and balance of payment gaps.

SIMULATION SYSTEMS: PARTIAL EQUILIBRIUM MODELS

As with the optimizing models, the use of partial equilibrium simulation models dominates by number of developed models. In most cases the models are a representation of major elements of one of the macro sectors shown in Figure 4. Beyond the LES applications mentioned in the previous section, there are numerous models which are commodity or commodity-policy specific. The generality of these models is, of course, limited.

There are two broad approaches to the development of these models: (1) To test behavioral responses - are farmers profit maximizers? and (2) To represent behavioral response according to a hypothesized structure - concessional aid receipts are a function of stock levels and the balance of payments. By its nature the first approach is a one-time efforts aimed at determining and measuring the characteristic behavior of a segment of a population or of an economic system. The second is most often used to evaluate the effectiveness of some particular policy over time. Both approaches generate information which is useful for policy analysis; the first to determine likely response and the second to test alternatives - we will concentrate on applications of the second type. (An example of the first type is Abbott(1979), who tested the response of 33 countries to changes in world grain prices to determine if these countries could be considered free or controlled markets. An extension of the Abbott model, applied to four East African countries, can be found in Gerrard(1981).)

A model, somewhat related to the Abbott and Gerrard approaches, but which incorporates more policy detail, is the Scobie(1981) model for Egypt. This model concentrates on wheat and cotton and balances import demand for wheat against aid receipts and in the face of subsidies and exchange constraints. This model is aimed at evaluating the effects of world prices, price controls and exchange earnings on wheat and cotton production, wheat consumption, food prices and wheat imports. The model is small, consisting of 23 equations and a total of 40 variables.

An example of the combination of simulation and optimization systems is a model of India by Krishna and Chhibber(1983). This model is specific to wheat and concentrates on government procurement and wheat imports. The model consists of 5 equations determining demand, production, government concessional sales, procurement and imports. It is used to predict those variables in response to excnange rates, issue prices, procurement prices and aid receipts through 1992. The authors then use a simple, dynamic linear programming model to produce optimal procurement and import patterns using the simulated values as upper and lower bounds -- there is no 'feedback' to the simulation model.

These are only a few of the many partial equilibrium models which have been developed, but they serve to show how many of the models are used and the flexibility required of any system intended for genereal application.

REQUIREMENTS FOR A GENERAL SYSTEM

From the diversity of application of the various systems it is apparent that no single model can hope to represent all possible cases. But there are some common elements and obvious differences between the various applications which help to define what a usable system must be capable of doing.

First, on the consumption side the full interaction of commodity choice should be possible. There are a number of complete demand systems which have been developed and these could be used. In addition there are several methods for developing complete systems, not especially data intensive, which can be used when the complete system is not available. Since we want to abstract from specific functional requirements, the framework should use the elasticity form of the demand parameters.

Second the production side of the system should allow for fixed as well as variable factors of production, range limits on inputs and minimum output constraints. The production system should develop factor demand under these constraints. The Linear Programming model is especially well suited this purpose but other formulations are also available. A general system should allow for either linear programming or functional representation of the production side, especially for the agricultural component -- this suggests allowing for a combined optimization/simulation system.

Third, the price formation component of the system must allow for taxes, subsidies, quotas, and range limits on retail and farm prices -- at least for food commodities. The determination of which sectors and commodities are 'controlled' should remain flexible.

Finally, the system should allow for varying degrees of disaggregation within the various sectors, with the detail aggreagated into a limited representation of the macro economy. This representation would include income by macro sector, balance of payments, employment (where possible), tax receipts, subsidy payments and a general measure of inflation.

1/ This is probably because when there are sufficient data to develop a general equilibrium model there are also sufficient data to develop a complete demand system.

2/ This particular formulation happens to use a translog multiple-input/output derivation of the supply function.

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