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In recent years, a large number of computer-based models have been developed to help the agricultural community analyze trends, identify problems, and evaluate policy alternatives. Over 50 models with potential for food and agricultural issue analysis were identified. These models vary by scope, size, methodology, and issues covered. They can be viewed as a hierarchical set of analytical tools which can be used to address several levels of problems, such as local issues of a specific crop, regional issues involving several farm inputs, national issues integrating nutrition with production policies, or global problems addressing population, wealth, and food. Many of the models identified are single or multicrop models and are usually confined to a particular region of the world. Other models are designed to aid understanding of specific policies or issues such as grain reserve costs under varying conditions. Still others are highly aggregated, treating the agriculture as a whole, and are intended to predict general levels of activity over the short run. A smaller number of large-scale models exist that are not limited to any particular time frame and, in some cases, are actually a series of interacting submodels combining agricultural and nonagricultural issues. These models attempt to portray the total food system, including key factors, such as demography, environment, and pollution, that influence the system. (Author/SC)

STUDY BY THE STAFF OF THE UNITED STATES GENERAL ACCOUNTING OFFICE

Food And Agriculture Models For Policy Analysis

Community and Economic Development Division - Food Staff
U.S. General Accounting Office
March 1977

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GAO identified over 50 models with potential for food and agricultural issue analysis. These models vary by scope, size, methodology, and issues covered. They can be viewed as a hierarchical set of analytical tools which can be used to address several levels of problems, such as local issues of a specific crop, regional issues involving several farm inputs, national issues integrating nutrition with production policies or global problems addressing population, wealth, and food.

Models described in this study have potential for analyzing many policy-related matters for food and agricultural decisionmakers. However, these models are only partial representations of reality based on certain assumptions of their designers.

CED-77-87

JULY 13, 1977

PREFACE

Concern over the integrity of food and agricultural data systems and the analytical tools used to provide policymakers with timely and relevant analysis prompted us to explore the potential new techniques hold for improving decisionmaking. Previous GAO reports to the Congress and reports from the Office of Technology Assessment and congressional hearings have addressed the need to improve agricultural and food data and analysis capabilities within the Federal Government.

One analytic tool that is gaining popularity in public and private sectors is the computerized model. This study describes several of these models that deal specifically with food and agriculture issues. The environment in which these models operate and their potential uses and limitations are also discussed.

We hope that this study will help analysts explore the nature and scope of models now in use and inform decisionmakers of models' potential usefulness for policy analysis.

This document was developed by Gary Boss of the Food Analysis and Coordination Staff with the cooperation of other offices. Questions regarding the content of this document should be directed to William E. Gahr, Assistant Director, on 275-5525.

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Director
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STUDY BY THE STAFF OF THE UNITED STATES GENERAL ACCOUNTING OFFICE

FOOD AND AGRICULTURE MODELS FOR POLICY ANALYSIS

D I G E S T

Within the past 4 years, tight food supplies have led to higher food prices, increased global hunger, and a growing concern over the impact existing policies have on food supply, demand, and prices. This concern has prompted many experts to reassess the food system and the complex international environment in which it operates.

A major outgrowth of this situation has been an increase in quantitative techniques designed to improve information processing, data analysis, and forecasting. While a great many techniques have been developed to achieve a variety of objectives, a large number of computer models exist that analyze expected consequences of food and agriculture policies over a period of time. In general, these models try to reflect the real food and agriculture system and can help users better understand complex interrelationships between supply and demand. Perhaps more importantly, these models attempt to help the user learn about the range of outcomes which may result from policy actions and inactions. Used in this manner, models are said to have great potential as an educational tool and as an aid to decisionmaking.

Models are widely used in many non-agriculture applications. For example, the military makes extensive use of simulation models for strategic situations, missile trajectories and battlefield conditions; social planners model urban systems for planning, social interactions and human speech; auto makers model the dynamics of car suspension systems; NASA models moon shots and so on.

Recently the Congress began to recognize that models have potential to aid understanding of agriculture system dynamics. Several committees now use large commercial models, and two subcommittees focus on computers and information systems. The Department of Agriculture has developed a number of models for forecasting.

<u>Tear Sheet</u>. Upon removal, the report cover date should be noted hereon.

MODEL SURVEY

With the idea that computer-based models could help improve policy analysis, GAO began a survey of food and agriculture models. The survey was to uncover and describe existing models with potential usefulness for policy analysis. Since GAO could not find any document listing or describing large numbers of models, it is publishing this report as a tool for model builders and potential users.

GAO identified and described over 50 models. Most of these models are designed for specific purposes and therefore have a more focused scope. Many are single or multicrop models and are usually confined to a particular region of the world. Other models are designed to aid understanding of specific policies or issues such as grain reserve costs under varying conditions. Still others are highly aggregated, treating the agriculture as a whole, and are intended to predict general levels of activity over the short run.

A smaller number of large-scale models exist that are not limited to any particular time frame and, in some cases, are actually a series of interacting submodels combining agricultural and nonagricultural issues. These models attempt to portray the total food system, including key factors like demography, environment, and pollution, that influence the system.

Although each model surveyed is designed for different purposes, all may be useful for some type of policy analysis. For example, the smaller specific purpose models and the larger commercial varieties used for forecasting are intended to offer systematic speculations about the future, which can help planners make decisions with ramifications for the future. The larger simulation models are designed to help estimate the outcomes of certain policy actions under varying conditions.

GAO found that many new models are constantly being developed while others are being revised and still others are being abandoned. This study does not cover all food and agriculture models, but the models described represent the types in existence today.

The growing complexity of the marketplace and the interdependence of issues strains decision-makers' ability to properly assess the outcomes of food and agricultural decisions. The types of advanced analytical techniques presented in this study are but a sampling of modeling efforts with potential to improve policy analysis. Although no judgments have been made as to which model or type of model is best for policy analysis--that depends on the questions asked--experience with models in nonagricultural situations suggests that models are being used more frequently in the policymaking process.

Tear Sheet

Contents

ABBREVIATIONS

CBO	Congressional Budget Office
CRIS	Current Research Information Service
CRS	Congressional Research Service
ERS	Economic Research Service
FAO	Food and Agriculture Organization
GAO	General Accounting Office
NAL	National Agricultural Library
NTIS	National Technical Information Service
OTA	Office of Technology Assessment
SCI	Science Citation Index
USDA	U.S. Department of Agriculture

CHAPTER 1

INTRODUCTION

Within the past several years, the international agricultural environment has undergone dramatic change. Weather-induced crop failures in several key areas of the world in 1972-73 led to widespread famine, virtual elimination of world food stocks, massive purchases on the world market, and higher prices. At home, farmers' incomes rose to new heights as unprecedented foreign demand all but depleted existing grain reserves despite full production efforts. Existing acreage controls, price supports, and Government controlled grain reserves were not being used as they were during the surplus era of the 1960's when food was abundant and cheap.

The 1973 Farm Act emerged during this time as a free market policy: minimum Government interference, low levels of price supports, and no costly grain reserves. However, it was not long before Government reentered the market place. Relatively tight food supplies, rising domestic food prices, and the Russian grain deal led the Government to halt some foreign sales and to negotiate a long-term supply contract with the Soviets. As the Congress begins its debate on a new farm bill, U.S. and world food supplies are becoming more plentiful, causing a growing concern about the adequacy of existing policies to cope with supply/demand fluctuations and with the uncertainties of the future.

As the world food system grows more interdependent, policy actions made at home have ramifications abroad. Decisions regarding supply agreements, price supports, reserves, and food aid influence foreign demand, prices, and hunger which in turn affect the price consumers pay for food and the amount farmers earn. Much concern stems from the fact that it is difficult to foresee future events and to evaluate how a policy or series of policies influences and interacts with other policies and events.

This concern about future events and potential consequences of policies has increased the need to better understand how agricultural systems operate. A major outgrowth of this need has been a proliferation of quantitative techniques designed to improve information processing, data analysis, forecasting, and policy evaluation. Many believe not enough analytic tools are available to evaluate and test potential policies for their probable effects.

Modeling is frequently suggested as a means for linking data with potential problems for use in evaluating policies. This suggestion is based on the belief that intelligent planning requires strong efforts to assess future developments as far as current techniques permit. Anything that could be done to structure, quantify, and focus expectations about the future could help decisionmakers.

DEFINING MODELS

A model is a representation of a system. It is constructed to show how a system can be expected to react under different conditions during a given period of time. Constructed properly, it illuminates and clarifies the interrelationships of component parts and of cause and effect, action and reaction. It allows people to assimilate and systematically analyze large numbers of variables which they otherwise could not do.

Models come in different shapes and sizes and are designed for different purposes. They can be classified a number of ways, including by

--methodology	econometric, systems dynamic, input-output, linear programing
--size	many equations, few equations
--time horizon	short run (up to 1 year), medium term (1 to 5 years), long run (over 5 years)
--function	economic projections, forecasting, scenario building
--geographical area	regional, national, global with regional interaction
--levels of aggregation	single crop, multicrop, sectoral, multisectoral
--issues covered	agriculture only, multi-issue

The food and agriculture models discussed in chapter 2 and listed in chapter 3 represent many of the characteristics just described. In general, these models are a collection of equations which attempt to describe the many interrelationships between supply and demand. Such factors as land, yields, investment, population, climate, and other key factors may be represented by variables in the model.

USING MODELS

Models have gained widespread use in business and government. They have influenced decisionmaking in some billion-dollar Federal programs. For example, the military has used a model that simulates strategic missile launchings, determining the probability of a successful launch under varying conditions. Models have been used to simulate the effect of population and employment on land use planning. Models are used in the securities and commodities market to predict behavior and in the auto industry for improving automobile design systems. In all of these instances, the model has been used to assess likely impacts throughout a system by altering variables and data.

The National Science Foundation recently sponsored a study on federally supported mathematical models. The study identified over 650 models and found that an increasingly large number are being used by Government and the private sector to represent and analyze complex socio-economic structures.

The Congress is also showing more interest in models: the budget committees, the Congressional Budget Office (CBO), the Congressional Research Service (CRS), and GAO have access to major econometric models. Other committees and staff are exploring other types of models for potential use.

The House Agricultural Committee and Congressional Budget Office have used agricultural models to estimate the cost to the Government of changes in commodity support prices. Both the Senate and House Agricultural Committees have used a large-scale national agricultural model to study the effects of different energy and environmental restrictions on the price of agricultural products.

SCOPE OF SURVEY

Since computer models were gaining popularity throughout Government and industry, we were interested in determining how models might be useful for our role of analyzing important policies in food and agriculture. We initiated this survey to identify the major models currently in operation that have potential for food and agricultural policy analysis, without regard to their size, mathematical foundation, structure, or location. We searched several data banks, researched current literature, and held discussions with leading model builders and model users in the Congress, executive branch, industry, and universities.

Although our information on models is reasonably current (we completed our research in January 1977), new models are constantly being developed and old ones modified and abandoned. Also, many models are quite limited in scope, are not operational or are not being used for one reason or another. We did not include such models in this survey.

METHODOLOGY

We identified the first list of models by talking with model builders, model users, and economists and researchers from Government, industry, and academia. Discussions were held with individuals from the Economic Research Service (ERS) of the U.S. Department of Agriculture, National Science Foundation, University of Illinois, Iowa State University, Office of Technology Assessment, Congressional Research Service, World Bank, and the American Marketing Association. Searches were made of computerized data banks using key words like agriculture, food, models, simulation, econometrics, and forecasting. The systems searched were:

National Agricultural Library (NAL)
National Technical Information Service (NTIS)
Dissertation Abstracts
Science Citation Index (SCI)
Enviroline
Biosis
Current Research Information Service (CRIS), US Department of Agriculture

Search abstract data--with written materials on some of the models, comments made by model developers, attendence at seminars in which models were discussed, and other published literature--provided the basis for our original identification and description of 68 models.

CRITERIA FOR MODEL SELECTION

In the initial list we included any model (mathmatical, computerized, or econometric) used to analyze, evaluate, or forecast food production, supply, demand, stocks, and pricing. Included were major economic or trade models that have an agricultural sector. Some of these models, such as global models and macroeconomic commercial models, are not necessarily limited to analyzing food and agricultural policy. Those with a developed agricultural sector or submodel were included in our list. We did not include models relating only to agriculture products not used for food, such as tobacco and cotton. We also excluded models that concentrated on the physical or biological science, such as a specialized model simulating the growth of plant life.

We constructed and mailed questionnaires (see app. II) to each of the 68 model developers to

--verify the accuracy of model descriptions and

--inquire about the present status of the model (for example operational, being modifed, or abandoned).

The questionnaire also asked the modelers' views on other models and on the future of modeling for policy analysis.

The questionnaires and a list of 68 models were sent to 54 U.S. developers and 6 foreign developers late in December 1976. (Some modelers have more than one model.) Followup telephone calls were made to those not responding by January 8, 1977. Of the 60 different modelers contacted, 56 provided responses, including 3 of the 6 foreign developers.

CHAPTER 2

MAJOR MODELS USED IN FOOD AND AGRICULTURE

Generally, models identified from our research can be divided into three main categories of those developed

--within the academic community,

--or used by the U.S. Department of Agriculture, and

--by private research firms either for commercial or noncommercial use.

Although models can be classified by size, structure, issue, geography, time horizon and so on, a useful way of classifying models is by their scope: they are world, national, single commodity, or food reserve oriented.

A large portion of the models were developed by university agriculture departments or by the U.S. Department of Agriculture, which has sponsored several university efforts. Many are single or multicommodity models and are usually designed for analyzing conditions in the United States. Over 60 percent of the models identified the majority of which deal with one or more specific crop are strictly limited in scope to the United States. Another 20 percent, frequently single or multicrop specific, confine their scope to regions within the United States. Still other models are designed to analyze the impact of specific Government policies, for example, grain reserve questions.

Several models, including a number of world and national efforts, are very large, incorporating agricultural and non-agricultural issues. These models try to model the total food system, either on a national or international scale, and have built in key influencing factors, such as demography, environment, energy and pollution. These models are actually a series of interacting submodels and may or may not be designed specifically for global food policy analysis.

Private research firms have developed a smaller number of large national models. These are well known efforts designed to make short run forecasts at the disaggregated single crop level of activity.

We did not attempt to verify or evaluate any of these models.

MAJOR USERS

A large majority of the models that were described as operational are being used by the Federal Government. These include the models developed for in-house use by USDA and the three major commercial models and others developed outside USDA. The Congress is a major user of several of the models.

USEFULNESS OF MODELS

The large growth in models over the past 4 years has caused doubts as to which model or models are most useful for food policy analysis. We asked developers to list those models they felt were best for food policy analysis. Over half the developers did not answer the questions. Several stated that no one model could be described as best since the type of questions asked affects the outcome. In all, 25 developers listed 20 different models with the majority getting 1 or 2 votes.

FOOD MODEL PANEL

GAO asked a number of leading agriculture economists and modelers for their views on models and policy analysis. (See app. VI for details.) Among other things, these experts felt that knowledge of existing models is inadequate, many models are poorly documented and policymakers need to be educated on the value of models. The experts suggested that some type of institutional mechanism is needed to help alleviate some of these problems. In general, the experts agreed that several current models could be used for meaningful policy analysis.

FUTURE OF MODELING

Response to the question on the future of models for food policy analysis varied from no comments to very lengthy ones. A majority of those responding felt that modeling would play an important role in future food policy analysis. Several stated that no one model could answer all questions on policy analysis and that a combination of models would have to be used. Respondents also felt that models would become more specialized and that a comparison of model outputs should and in fact would become more commonplace.

Some of the more general comments made were: (1) there has been a proliferation of new models in recent years, (2) models are needed due to the complexity of food policy issues, (3) there is a steep learning curve associated with model building and an understanding of the complex interrelationships that accompany food policy issues, (4) models are very expensive, and (5) models can be very useful if carefully designed and used with care and understanding of their limitations. A few other respondents suggested that model limitations must be recognized and model use should be tempered with judgment. Mixed reactions were received concerning how sophisticated the underlying economic theory in models should be: some felt more sophistication is needed while others think models should be simpler.

STATISTICS FROM QUESTIONNAIRE

The model developers answered the questionnaires (app. II) on 60 models. The breakdown of responses for each main question is given in the following table with the percentages.

Total no. responding to question	Question	Number of responses	Percent
58	What is the primary scope of your model? (Check one)		
	International	17	29
	National	34	59
	Regional	7	12
		58	100
57	What are the primary subject areas addressed in your model? (Check all that apply)		
	Food or Agriculture	57	100
	Energy	12	21
	Population growth	5	9
	Pollution	7	12
	Wholesale trade	11	19
	Retail trade	7	12
	Finance	5	9
	Other (please specify)	17	30

Total no. responding to question	Question	Number of responses	Percent
57	In your model, how are food products or agricultural commodities aggregated? (Check one)		
	Not applicable--food products or agricultural commodities are not covered by the model.	0	0
	Model deals with one specific food product.	14	25
	Model deals with several food products.	27	47
	Model deals with several food products all aggregated as one (e.g., total food supply).	9	16
	Other (please specify)	7	12
		57	100
57	What is the current status of your model? (Check one)		
	Abandoned	8	14
	Being developed, not operational yet	7	12
	Operational but refinements or revisions planned	42	74

Total no. responding to question	Question	Number of responses	Percent
	Operational, no further refinements planned	0	0
	Other (please specify)	0	0
		57	100
42	If your model is operational, how would you classify the current major users? (Check all that apply.)		
	State and local Government	7	17
	Federal Government, executive branch	29	69
	The Congress	13	31
	Private industry	11	26
	Academic (or other research)	31	74
	Other (please specify)	8	19
21	Do you know of other models that should be included in the list?	21 additional models recommended, (see p. 32)	
24	Excluding your model, what model would you consider best for evaluating Federal food policies on national and international levels? (Please fill in the blanks)		

Total no. responding to question	Question	Number of responses	Percent (note a)
	National:		
	POLYSIM	11	39
	Iowa State	5	18
	Cross Commodity Forecasting System	4	14
	NIRAP	3	11
	Agrimod	2	7
	Model of Food and Fiber System	1	4
	EPA Model	1	4
	Consumer Price Model	1	4
		28	100
	International:		
	Grain-Oilseed-Livestock	5	24
	World Integrated Model	2	10
	MORIA	2	10
	World Food Model	2	10
	FAO Commodity Projections	2	10
	World II	2	10
	International Cross Impact World Model	1	5
	Food 1	1	5
	Japan Ministry of Agri Model	1	5
	Explore-Multi-trade 85	1	5
	FAO Dietary Projections	1	5
	CHAC	1	5
		21	100
40	Briefly describe your views on the future role of models for evaluating food policy.		

a/ will not add to 100 percent due to rounding

Total no. responding to question	Question	Number of responses	Percent
	More use of several appropriate models	8	20
	Future is bright and growing	16	40
	For success must temper model results with judgment	7	18
	Will be base on more complete, sophisticated economic theory	7	18
	Will be simplified	2	5
	Limited future	2	5
	Other	7	18

CHAPTER 3

MODEL DESCRIPTIONS

From our initial list of 68 models we identified 57 agriculture-related models, which are either being developed or are fully developed and operational. The 57 models identified are presented as follows:

	Number of models	Page
1. World models	15	14
2. National models	22	19
3. Single commodity models	12	26
4. Food reserve models	8	29

We have also included a list of, in most cases, the name and developer of 21 other models that questionnaire respondents felt should be included on our list of 57 models. (Time did not permit our obtaining additional information on these.)

Although the list of models is incomplete, we feel that it does contain the majority of current modeling efforts that are closely related to food policy analysis.

World Models

Title	Developer	Description
1. World Integrated Model	M. Mesarovic, Case Western Reserve University, Cleveland, Ohio	Designed to assess the consequences of alternative policy scenarios on the world food situation. Disaggregates world into 10 regions and projects to year 2025.
2. World 2	J. Forrester, Massachusetts Institute of Technology, Cambridge, Mass.	Interrelates five world subsectors--population, capital investment, natural resources, food production, and pollution. Effects of alternative policies on world food supplies are analyzed to the year 2100.
3. World 3	D. Meadows, Dartmouth College, Hanover, N.H.	Uses same world systems dynamics and subsectors as World 2. However, disaggregates to a greater degree and provides greater interrelationship among sectors.
4. MOIRA	Linnenmann, Free University, Amsterdam, Netherlands	Global in scope distinguishing 106 geographic units. Agriculture sector is explicitly modeled; growth of nonagricultural sector is exogenous. Examines the influence of factors, such as economic growth

Title	Developer	Description
		population increases, world food prices, and aid on the incidence of malnutrition.
5. Latin American World Model	Bariloche Foundation, Argentina	Constructed from the developing countries' viewpoint to examine the feasibility of poorer countries achieving an adequate living standard in terms of food, housing health care, and education. Disaggregated into one developed and three underdeveloped regions.
6. Explore-Multitrade 85	Battelle Memorial Institute, Richland, Wash.	Worldwide model dealing with agriculture supply, demand, and trade flows. Provides medium-to long-term forecasts for up to 70 commodities within 10 nations and trade flows for commodities. Projections on production prices, costs, profits, imports, and exports are given.
7. Globe 6	Battelle Memorial Institute, Richland, Wash.	Divides world into two regions--developed and developing. Major elements include resources, agriculture, population, food, industry, and pollution. Designed

Title	Developer	Description
		for scenario analysis to the year 2050.
8. World Grain, Oilseed. Livestock (GOL)	A. Rojko, ERS USDA, Washington, D.C.	Worldwide 28-region model of the major grain-oilseed-livestock complex is analyzed physically and a world price profile calculated. Feed demand of certain commodities as inputs into production of other (livestock) commodities is specifically analyzed.
9. Social and technological alternatives for the future	C. Freeman, Univ. of Sussex, U.K.	Dynamic and simple structural models are being developed, where appropriate, to examine selected aspects of the world food situation, in particular the choice of agricultural technology and the potential interactions between changing climate and food production.
10. World Price Equilibrium Model	Food and Agriculture Organization (FAO), Rome, Italy	Short-term projections of world demand and supply of commodities.
11. On the future Japan and the World - A Model Approach	Y. Kaya, Japan	A number of interrelated projects, mainly concerned with the effect of world trends on Japan, and the reduction of global

Title	Developer	Description
		demand-supply gaps between developed and developing nations.
12. World Rice Trade Model	W. Gregory, ERS, USDA, Washington, D.C.	Total world rice economy is divided into 38 countries or regions. A set of equations denotes production, consumption, price linkages, and policy or physical constraints. The model has been used to increase understanding about how technology, weather, and domestic and international policies affect prices and trade.
13. World Food Projection and Planning Model	Takashi Takayama, Univ. of Illinois, Urbana, Ill.	Spatial and temporal equilibrium models that incorporate population and income growth rates to generate equilibrium prices, consumption, supply, trade and carryover quantities for 10 commodities, 20 regions and the 1976-85 period. Also, price stabilization and world grain reserve policies are examined.

Title	Developer	Description
14. A Regional Crop and Livestock Model of U.S. Agriculture	T. Reynolds, N.C. State Univ., Raleigh, N.C.	An econometric model of U.S. crop and livestock production and income for 10 farm production areas with market submodels. Crops include wheat, feed grains, soybeans, and cotton. Purpose is to examine policy and export alternatives.
15. Japan Ministry of Agriculture Projection Model (JAM)	Japan Ministry of Agriculture, Japan	Forecasts equilibrium prices, consumption, supply quantities and carryover qantities of 11 major food products every year from 1975 to 1985 for 25 world regions.

National Models

Title	Developer	Description
1. Project Agrimod	Systems Control, Inc., Palo Alto, Calif.	Dynamic simulation model for analyzing the impact of agricultural and energy policy on U.S. food production and consumption over a 10-20 year period.
2. National - Interregional Agricultural Projections	L. Quance, ERS, USDA Washington, D.C.	A computerized simulation of U.S. agriculture, used to project and analyze alternative futures based on differing scenarios and policy decisions through the year 2025.
3. Model of Agriculture Policy, Land and Water Use	E. Heady, Iowa State Univ., Ames, Iowa	National-interregional programing and simulation model of agricultural productive capacity, policy, land and water use, and environmental impacts.
4. POLYSIM	D. Ray, F. Moriak, Okla. State Univ., Stillwater, Okla.	Comprehensive computerized model of agricultural sector of U.S. economy used in policy analysis. Provides 5-year projections of changes in commodity supplies, domestic use, exports, prices, and farm income-at the national level resulting from an agricultural policy

Title	Developer	Description
		change or changes in yield or expert expectations.
5. National Systems Dynamics Model	J. Forrester, MIT., Cambridge, Mass.	Designed to help solve pressing national problems and issues, including economic growth, agriculture, inflation, taxes, energy, education, etc. Ultimately will project to the year 2050.
6. Econometric Model of U.S Livestock-Feedgrains Economy	D. Heien, ERS, USDA, Washington, D.C.	Econometric model used for forecasting and impact analysis. Commodities covered include beef, pork, chicken, turkey, eggs, dairy products, corn, wheat, sorghum, soybeans, soybean meal and oil. Retail farm prices, slaughter numbers, produc tion, acreage, and yield are determined.
7. Cross Commodity Forecasting System	W. Boutwell, Comm. Econ. Div., ERS, USDA, Washington, D.C.	System consists of annual econometric models for 13 individual commodities or commodity groups. Individual models can be used to forecast for their own commoditiy or as part of whole system Used for forecasting. and various impact analyses.

Title	Developer	Description
8. Agriculture - General Economy Linkage Model	G. Schluter, ERS, USDA, Washington, D.C.	Model of U.S. agricultural sector designed to expand agricultural economic intelligence available in larger national models, such as Wharton's.
9. Energy Policy and Economic Growth	E. Hudson, Data Resource Inc., Mass. and D. Jorgenson, Harvard Univ., Cambridge, Mass	Model of U.S. economy with nine intermediate sectors, including agriculture. A detailed projection of demand and supply, price and cost, and imports and exports is made for each sector for the years 1979-2000.
10. CHAC	R. Norton, International Bank for Reconstruction, Washington, D.C.	Programing model of Mexican agriculture with consumer demand behavior and endogenous prices. Contains 20 producing locations and over 2000 production technologies. Used by Mexican government to simulate many policy alternatives, including pricing policies.

Title	Developer	Description
11. National Model of Energy Use in Agricultural Production	D. Dvoskin, Iowa State Univ., Ames, Iowa	A large-scale interregional linear programing model of U.S. agriculture constructed to evaluate the economic and environmental impacts of various energy situations in agricultural production.
12. Research and Development Priorities for Food Research	P. Kruzic, Stanford Research Institute, Palo Alto, Calif.	Dynamic simulation model designed to analyze "what if" type questions in several areas of interest--not specifically agriculture.
13. Two-Sector Model of Agricultural Resource Adjustment and Structural Change-With Farm Commodity Program-Policy Variables	F. J. Nelson, ERS, USDA, Washington, D.C.	A two-sector (crops and livestock) aggregate simulation model of U.S. agriculture which uses a resource adjustment approach to supply response. Includes aggregate resource productivity, farm numbers and sizes, and price variability measures (risk proxies) as endogenous variables.

Title	Developer	Description
14. Wharton Agricultural Model	D.T. Chen, Wharton Econometric Forecasting Associates (EFA), Philadelphia, Pa.	A complete U.S. agricultural sector model. Contains 4 blocks, over 260 equations, and 500 variables which describe 17 commodities and farm incomes and expenditure flows. Integrated with the Wharton Macro models for forecasting and policy analysis.
15. Short-Term Forecasting Models for the Following Countries - France, West Germany, Italy, The Netherlands, and Belgium-Luxembourg	W. Kost, For. Demand & Comp. Div., ERS, USDA, Washington, D.C.	Focus on the grain-oilseed-livestock sectors. Each country model contains three submodels: production, feed consumption, and food consumption.
16. A Quadratic Programming Model of the U.S. Food and Fiber System	T. Miller, ERS, USDA, Washington, D.C.	Estimates the competitive equilibrium situation resulting from U.S. domestic and export food and fiber requirements. Gives consistent estimates of prices and quantities for farm inputs and outputs.

Title	Developer	Description
17. Aggregate Income and Wealth Simula Model	J. Penson, D. Lins, and C. Baker, ERS, USDA, Washington, D.C.	Short-term model that forecasts components of the income accounts, balance sheet, and sources and uses of funds statement for the farm sector.
18. Consumer Price Model	Research Triangle Institute, Research Triangle Park, N.C.	Uses cost-push assumption to provide projections of the impact of an increase in the cost of production on the price of 477 consumer products.
19. National Agricultural Sector Study (NASS)	V. Sorenson and S. Thompson, Mich. State Univ., Mich.	National agriculture model containing a large international component. Can be used for forecasting and policy analysis.
20. Chase Econometric Agricultural Forecasting Model	Chase Manhattan Bank, New York, N.Y.	National 2-year quarterly and 10-year annual agricultural model for major crop and livestock products, farm income, and wholesale retail food price indexes.
21. DRI Agriculture Model	Data Resources, Inc., Lexington, Mass.	National agriculture model with supply and demand information for 20 commodities, farm income, and balance sheet. Incorporates weather data. Can be used for forecasting and policy analysis.

Title	Developer	Description
22. Feed and Livestock Evaluating System	P. Velde, ERS, USDA, Washington, D.C.	A mathematical programing system of models to quantitatively measure the impact of changes in supplies, demands, and ending stocks of specific nutrients, such as a certain type of protein on specific amino acids on the world or U.S. feedstuff commodities.

Disaggregated Single Commodity Models

Title	Developer	Description
1. Dairy Policy Model	ERS, USDA, Washington, D.C.	Model structured to simulate industry as currently organized. It includes equations to represent (1) Government pricing strategies, (2) producer behavior, (3) consumer behavior, and (4) Government support activity. Designed to simulate the impact of alternative policies for the dairy industry.
2. Resource Use of Alternate Beef Production System	G. Ward and P. Knox, Colo. State Univ., Fort Collins, Colo.	Model of beef production systems in Colo. and neighboring States.
3. COPLAN	Regional Systems Program, Colo. State Univ., Ft. Collins, Colo.	Resource allocation on small ranches.
4. Reactive Programming Model of the Fluid Milk Industry	J. Riley and L. Blakley, Okla. State Univ., Okla.	Designed to determine equilibrium market prices, equilibrium consumption, and minimum cost flows between surplus and deficit markets under alternative price or structural conditions in the fluid milk industry.

Title	Developer	Description
5. Systems Analysis of the Livestock Industry	R. Crom, ERS, USDA, Washington, D.C.	Model of beef-pork sectors. Estimates on a quarterly basis, prices, output, and livestock inventory
6. Egg Price Prediction Model	W. Henson, Penn. State Univ., Univ. Park, Pa.	Econometric model designed for forecasting egg prices.
7. A Systems Model of the U.S. Processing Tomato Industry	E. Jesse, ERS, USDA, Washington, D.C.	Uses econometric techniques to evaluate potential structural adjustments in the U.S. tomato subsector.
8. Market Organization, Policies and Programs in the Dairy Industry	R. King, N.C. State Univ., Raleigh, N.C.	Model in process of development consists of spatially oriented structure with demand supply, and transfer costs for fluid and manufacturing milk subject to administrative decisions with respect to Class I prices and Government purchases of manufacturer products.
9. Economic Analysis of Daily Hog Price-Quality Fluctuations	R. Leuthold, Univ. of Ill., Urbana, Ill.	Two-equation model explains short-run hog price and quantity fluctuations at major U.S. terminal hog markets.

Title	Developer	Description
10. An Economic Appraisal of the Beef Production Industry in the Cornbelt and Lake States	N. Martin, Univ. of Ga., Athens, Ga.	Model for Midwest agriculture to evaluate the impact on future beef production of changes in prices of beef and substitutes for beef, changes in input prices, and level of technology.
11. Systems Analysis of the Hog-Pork Subsector	W. Vincent, Mich. State Univ. and R. Crom, ERS, USDA Washington, D.C.	A simulation model of the U.S. hog-pork subsector. Structured to trace hog production and eventual disposition through production-feeding, slaughtering-processing and distribution-consumption components under different policy alternatives.
12. Grain 1	L. Brzozowski, Dartmouth College, Hanover, N.H.	Computer simulation model of U.S. wheat production which includes the decision rules and information links used by farmers as they formulate production decisions. Can be used for policy analysis and conditional forecasts of system behavior.

Food Reserves Models

Title	Developer	Description
1. Simulation of Grain Buffer Stocks	S. Reutlinger, International Bank for Reconstruction and Development, Washington, D.C.	A stochastic simulation model designed to calculate the efficiency, equity, trade, and stabilization impacts on a less developed country of an investment in grain reserves. Can also be used to evaluate international grain reserve policies.
2. CDTY 10	L. Brzozowski, Dartmouth College, Hanover, N.H.	A stochastic simulation model capable of assessing the impact of large export sales of wheat which are made at different points in the production cycle. Prices, production, carryover, and Government costs are measured.
3. An Optimization Approach to Grain Reserves for Developing Countries	D. Johnson and D. Sumner, Univ. of Chicago, Chicago, Ill.	Model is designed to calculate optimal grain reserves for developing countries and regions. The basic unit of analysis is a single country or region over a time horizon greater than 1 year.

Title	Developer	Description
4. Reserve Stock Grain Models for the World, and the United States 1975-85.	W. Cochrane, Univ. of Minn., Minneapolis, Minn.	A world grain model and a U.S. wheat model are used to estimate what size reserves stocks are required to achieve some price stabilization goal with some degree of probability. The models are based on supply-demand equilibrium theory. Prices are determined in (1) free market situation and (2) with application of different reserve stock decision rules.
5. GRAINSIM	R. Walker, J. Sharples, and F. Holland, ERS, USDA, at Purdue Univ.	Designed to analyze Government buffer stock management rules. Contains shortrun supply-demand functions for 1976-82. Predicts how buffer stock management rules effect grain supply and demand, livestock, income of farmers, prices, and Government costs.
6. WHEATSIM	R. Walker, J. Sharples, and F. Holland, ERS, USDA, Washington, D.C.	Designed to analyze government buffer stock management rules. Contains shortrun wheat supply-demand functions for 1976-82. Predicts how buffer stock management rules affect wheat supply and demand, income of farmers, prices, and Government costs.

Title	Developer	Description
7. Grain Reserve Sizing Model #1	D. Eaton, Univ. of Texas, Austin, Texas	Model develops a procedure to calculate a lower limit on the size of a world grain reserve to reliably stabilize supplies of grain over the period 1975-2000.
8. Grain Reserve Sizing Model - #2	D. Eaton Univ. of Texas, Austin, Texas	Model develops procedures to size a world grain reserve to achieve multiple public objectives. These include supply stabilization, price stabilization, consumer interests, farmer interests, and economic efficiency.

The following is a listing, by title and developer, of 21 models which questionnaire respondents identified. They were not included on the original list of 68 models. We have not tried to further document the 21 nor to determine their present status.

	Title	Developer
1.	Food 1 - A Model for Prediction of World Food Production and Allocation	Calvin B. Dewitt Institute for Environmental Studies, Univ. of Wis.
2.	KASM-Korean Agriculture Simulation Model	Glen Johnson and G.E. Rosmiller Mich. State Univ. East Lansing, Mich.
3.	Interactive Cross Impact World Food	Selwyn Engar, twenty year forecasts, Center for Futures Research Univ. of Southern Calif.
4.	Sarnis	Univ. of Calif. Berkeley, Calif.
5.	A Stochastic Model for Estimating Future Disaster Payments Under the 1973 Farm Act	Tom Miller Comm. Econ. Div./ERS/USDA
6.	National-Interregional Model of U.S. Agriculture	Fred Arnold EPA Computer Center Washington, D.C.
7.	Food Impacts by Major World Regions	Dr. Donald Mitchell Michigan State Univ.
8.	TRIM	Harold Beebout Washington Policy Studies Group Mathematics Incorporated Washington, D.C.
9.	FAO Commodity Projections FAO Dietary Projections	FAO, Rome

	Title	Developer
10.	U.N. World Model	
11.	Agriculture Planning Model of Iran	Bruce W. Cone Battelle Memorial Inst. Richland, Wash.
12.	Simulation Model of the Rapeseed Economy of Alberta and Saskatchewan, Canada	Bruce W. Cone Battelle Memorial Inst. Richland, Wash.
13.	REFLOW	D. A. Jameson College of Forestry and Natural Resources, Colo. State Univ. Ft. Collins, Colo.
14.	GOAL	E. T. Barlet
15.	Revision of Reactive Programming	Verner Hunt Miss. State Univ. Starkville, Miss.
16.	Model Including Economics of Scale in Milk Processing	M. C. Conner and W. T. Boehm, Va. Pol. Inst. and S.U. Blacksburg, VA
17.	Net Trade Model	William E. Kost Foreign Demand and Comp. Div., ERS, USDA
18.	Net Trade Model -Coarse Grain	William E. Kost Foreign Demand and Comp. Div., ERS, USDA
19.	A Hybrid Probablistic System Dynamics Model of the United States Agriculture	Christian J. Donahue the Futures Group Glastonburg, Conn.
20.	BACHUE	G. Rogens World Employment Planning, I.L.O. Geneva, Switzerland
21.	SARUM	P. Roberts Systems Analysis Research Unit, Department of Envir. London, U.K.

Title		Developer
22.	Dynamic Hoc Cycle	Dennis Meadows, Dartmouth College Hanover, N.H.
23.	Dairy Farm	Philip Budzik, Donella Meadows, Dartmouth College Hanover, N.H.

CHAPTER 4

OBSERVATIONS

Our survey uncovered many models that appear to have potential for analyzing food and agriculture policies and issues. These models (described in ch. 3) represent the more significant modeling efforts we determined from our search of data sources and from discussions with model builders and users. About 20 of these models are actively used in Government and industry. More than 200 separate models can perform some type of food and agriculture analysis. However, because some models are constantly being developed and others modified and abandoned, a precise inventory of all models in existence cannot be developed.

Models are used for a variety of purposes by a variety of organizations. For example, several models are used primarily for forecasting a single crop, a series of crops, or an entire agriculture sector over a period of time. Used to assess probabilities of future outcomes, such models can provide policymakers with systematic speculations about the future. Many large commercial econometric and smaller special purpose models provide this technique. Several of the global models are designed for broad policy questions and cover longer time horizons. These models are designed to answer "what if" questions, allowing users to specify a series of assumptions and then learn the range of outcomes which may result from their actions or inactions.

Without actually testing each model it is difficult to judge what model or models would be best for any one series of policy questions. The larger, highly aggregated national and global models appear to be designed for broader policy questions that require consideration of international ramifications and multiple issues such as population and energy. These models typically have a longer time horizon capability although some of the more specific purpose models also allow for long term analysis.

The smaller, single or multiple crop models and the grain reserve efforts are typically used for shorter time frame analysis and can handle more specific policy questions.

Several experts agree that probably no one model will be able to provide analyses for all types of policy questions. The capabilities of each model differ in terms of level of aggregation, assumption, and range of issues covered. This fragmentation of models has led many experts to suggest that some kind of institutional mechanism be established to serve as a focal point for models. Such a mechanism could develop consistent language, documentation standards, and a means for classifying and describing various types of models. Underlying this need for a centralized mechanism is the belief that modelers need to better educate policymakers of models' potential usefulness in decisionmaking.

Those supporting the use of models for policy analysis cite that models:

--Identify new policy options that normally are overlooked.

--Detect important variables in a situation that might otherwise be neglected.

--Serve as an early warning device and spot new opportunities for problem solving.

--Recall specific facts and trends on critical issues.

--Provide alternative scenarios of the future according to a specific set of assumptions.

--Provide a series of expected outcomes of particular policy options under consideration by policymakers.

Limitations of using models include:

--As partial representations of reality, they cannot always identify or quantify all factors which affect system behavior.

--To a certain extent, they reflect the biases of their developers.

--Data base inadequacies can make their results unreliable.

--Validation can be extremely difficult, if not impossible in some circumstances, because they are complex.

GLOSSARY

Aggregation: Relates to degree which terms are combined together, for example, combining wheat, corn, and soybean into one term: grain.

Algorithm: A mathematical process carried out according to prescribed steps which leads to a proven result.

Base period: The time period selected to determine the base values of variables for use in current planning and programing.

Computer program: A systematic plan for solving a problem on a computer.

Computer simulation: Using a computer program to represent the system. See Simulation

Correlation: Statistical technique used to determine the degree to which variables are related or associated.

Data: Data are facts, symbols, or observations. Data are usually unevaluated, unorganized, and thus, are only potential information.

Demand: The schedule of quantities of goods or services that buyers are willing and able to purchase at given prices.

Demand-supply gap: The difference between quantity demanded and quantity supplied at a given price.

Disaggregated: A system or unit broken down into the smaller components which comprise it. See Aggregation.

Documentation: A complete system description in understandable form to be used to teach, operate, maintain, modify, and redesign a system.

Dynamic model: 1. One whose properties, features, or attributes are expected to alter with the passage of time. 2. One which requires time as an explicit variable.

Dynamic simulation: Reproducing the behavior of a system as it operates over time. See Simulation

Econometrics: Mathematical formulation of economic theories and the use of statistical techniques to accept or reject the theories.

Econometric model: A set of related equations used to analyze economic data through mathematical and statistical techniques. Depicts quantitative relationships that determine results in terms of economic concepts, such as output, income, employment, and prices. Used for forecasting, estimating the impact of alternative assumptions, and for testing various propositions about the way the economy works.

Elasticity: A numerical measure of the responsiveness of one variable to changes in another.

Endogenous variable: A variable, the magnitude of which is dependent on and determined by the model being studied.

Exogenous variable: A variable which is wholly independent of the model being studied; that is, a variable determined by outside influences.

Feedback: The process of obtaining system outputs, comparing them with desired results, and making the necessary corrections--either automatically or through human intervention.

Input-output analysis: A systematic technique for quantitatively analyzing the interdependence of producing and consuming units in an economy.

Linear programing: A mathematical technique that assumes linear relationships between variables and produces optimal solutions to problems concerning resource allocation and scheduling, subject to one or more limiting constraints.

Macroeconomic: Refers to the division of economics that deals with aggregates, such as total income, total output, total employment, and the general level of prices and wages in the economy being studied, which is usually the national economy.

Model: A representation of the relationships that define a situation under study. A model may be a set of mathematical equations, a computer program, or any other type of representation, ranging from verbal statements to physical objects.

Model, grain reserve: Designed to focus on those factors and relationships that determine world and/or national food stockpiles.

Model, mathematical: Model constructed with the use of mathematical symbols.

Model, national: A model that focuses on a single country or nation. Designed to analyze the impact of various internal and external forces on the general economy and/or the agricultural sector of that nation alone.

Model, single commodity: Simulates the factors and interrelationships that determine the production, distribution and consumption of a single food commodity on a global, national, or regional scale.

Model, world: Designed to simulate the behavior and interactions of all regions or countries of the world either in terms of one specific area of interest, such as agriculture, or by focusing on several areas at the same time, such as energy, pollution, food, population, etc.

Optimization: A determination of the best mix of inputs to achieve an objective.

Policy analysis: Analysis of the goals, purposes, and principles that guide an agency. Provides direction and methodologies for design and identification of preferable alternatives relating to policy issues.

Regression analysis: Analysis to determine the extent to which which a change in the value of one variable (the independent variable) tends to be accompanied by a change in the value of another variable (the dependent variable).

Scenario: A narrative description of the problem or operation under analysis, including the sequence of events, environment, scope, purpose, and timing of actions.

Simulation: A technique for reproducing the dynamic behavior of a system as it operates over time.

Simultaneous equations: Two or more equations used together in the same problem and having unknowns of the same value.

State variables: The static structures of a simulation model.

Static model: One that need not employ time as an explicit variable. One whose properties or attributes are not observed to change with the passage of time.

Supply-demand equilibrium: Reached only when the quantity demanded equals the quantity supplied.

System dynamics: Based on the traditional management process, and feedback theory. The approach is to construct equations that represent levels or accumulations within a system and rates of flow that transfer accumulations from one (area) to another. Many feedback loops are used. They either help attain desired values for levels or contribute to persistent growth or decline of levels.

Variable: A property of the system or its environment that assumes different values and whose value directly or indirectly affects system performance.

Variable, dependent: A variable whose changes are tested as being consequent upon changes in one or more other variables.

Variable, independent: A variable whose changes are regarded as not dependent upon changes in other specified variables.

Sources

Computer Simulation Methods To Aid National Growth Policy, Futures Research Group, Congressional Research Service, Library of Congress. Appendix A glossary.

Glossary for Systems Analysis and Planning - Programming - Budgeting, U.S. General Accounting Office, Oct. 1968.

Glossary for Public Program Analysis, Association for Public Program Analysis, 1973.

Technical Assistance Group/SA

APPENDIX II

APPENDIX II

SURVEY QUESTIONNAIRE

Model title: ____

____

2. Developer's or Project leader's name: ______________________________

____

3. Respondent's name: ______________________________

____

4. Respondent's title: ______________________________

____

5. Please read the short description (abstract) of your model on page _____ of the attached material.

   Is this an accurate description of your model: (Check one.)

   ☐ Yes

   ☐ No--If no, please write a short (35 words or less) description of your model in the space below.

   ____

   ____

   ____

   ____

6. What is the primary scope of your model? (Check one.)

   ☐ International

   ☐ National

   ☐ Regional

Page 1

7. What are the primary subject areas addressed in your model? (Check all that apply)

- [ ] Food
- [ ] Agriculture
- [ ] Energy
- [ ] Population growth
- [ ] Pollution
- [ ] Wholesale trade
- [ ] Retail trade
- [ ] Finance
- [ ] Other (please specify) ________________

Additional Comments: ________________

8. In your model, how are food products or agricultural commodities aggregated? (Check one.)

- [ ] Not applicable--food products or agricultural commodities are not covered by the model.
- [ ] Model deals with one specific food product.
- [ ] Model deals with several food products.
- [ ] Model deals with several food products all aggregated as one (e.g., total food supply).
- [ ] Other (please specify) ________________

9. What is the current status of your model? (Check one.)

- [ ] Abandoned (skip to 11)
- [ ] Being developed, not operational yet (skip to 11)
- [ ] Operational but refinements or revisions planned
- [ ] Operational, no further refinements planned
- [ ] Other (please specify) ________________

10. If your model is operational, how would you classify the current major users? (Check all that apply.)

- [ ] State and local Government
- [ ] Federal Government, Executive branch
- [ ] U.S. Congress
- [ ] Private industry
- [ ] Academic (or other research)
- [ ] Other (please specify) ________________

11. Do you know of other models that should be included in the list? (Check one.)

- [ ] Yes-- If yes, please list the additional models in the space below. (Please include name, developer, location, etc., if known.)
- [ ] No

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 APPENDIX II

12. Excluding your model, what model would you consider best for evaluating Federal food policies on national and international levels? (Please fill in the blanks.)

National: ______________________________

____

International: ______________________________

____

13. Briefly describe your views on the future role of models for evaluating food policy.

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14. ADDITIONAL COMMENTS: If you have any additional comments on any of the points covered, or related topics, please write your comments in the space below. Your views are greatly appreciated.

Thank you.

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CRIS ABSTRACTS

This section lists 27 research programs which were identified through a search of the Current Research Information System (CRIS). CRIS is a computer-based information storage and retrieval system sponsored by the U.S. Department of Agriculture and is designed to provide ready access to information on the research activities of USDA State Agricultural Experiment Stations and other cooperating institutions. The 27 research projects represent the use or development of models that may be useful for food policy analysis.

	Title	Developer
1.	Impact of Changes in World Food Supply-Demand Upon Selected Agricultural Markets	D. G. Anderson University of Nebraska Lincoln, Neb.
2.	Market Potential for Soybeans in Georgia and the Southwest	R.F. Anderson ERS/USDA-Georgia Agri. Exp. Station
3.	Demand and Supply Analysis for Fruits and Vegtables	J.L. Baritell ERS/USDA Washington, D.C.
4.	Aggregate Demand Analysis	T.N. Barr ERS/USDA Washington, D.C.
5.	Impact of Rising Energy Costs on Kansas Rural Development Especially Livestock and Meat	A.W. Biere Kan. State Univ.
6.	Econometric Analysis of the U.S. Position in the World Wheat Economy	L.L. Blakeslee Wash. State Univ.
7.	Economic Analysis of Production and Marketing: The Fruit Industries	R.W. Bohall ERS/USDA Washington, D.C.
8.	Supply-Demand Balances In Agriculture	G.E. Brandow Penn. State Univ.
9.	Household Behavior and Demand Analysis	C.R. Burbee ERS/USDA Washington, D.C.

Title		Developer
10.	U.S. Food and Agricultural Policy in Context of World Economic and Agricultural Development	W. W. Cochrane Univ. of Minn.
11.	Importance of Agricultural Commodity Exports to the Economy of Oklahoma	H.E. Drummond Okla. State Univ.
12.	Domestic and Foreign Demand for Red Meat and By-Products	L.A. Duewer ERS/USDA Washington, D.C.
13.	Impact of changes in world Food Supply-Demand Conditions Upon Selected Agricultural Factor Markets	R. W. Fox Univ. of Ariz.
14.	Consumer Demand and Prices for Meat and Produce and Their Impacts of Farm Product Markets	T. F. Glover Utah State Univ.
15.	Energy in Western Agriculture-Requirements, Adjustments and Alternatives	W. E. Johnston Univ. of Calif.
16.	Technological and Structural Changes in the Marketing of Beef	S. H. Logan Univ. of Calif.
17.	Aggregate Demand and Supply Analysis	J. W. Matthews ERS/USDA Washington. D.C.
18.	Economic Impact and Market Implications of Excess Supply in Beef Cattle	J. M. Marsh Mont. State Univ.
19.	Market Forces Which Determine Prices for Milk and Fruits and Vegetables	W.L. Park Rutgers Univ.
20.	Consumption and Demand for Selected Food and Fiber Products	F. Proshaska Univ. of Florida

APPENDIX III

	Title	Developer
21.	Spatial and Temporal Aspects of Demand for Food Products	F. Proshaska Univ. of Fla.
22.	Price Relationship of Michigan Tree - Fruits	D. Ricks Mich. State Univ.
23.	Michigan Agricultural Sector Study (MASS)	G.E. Rossmiller Mich. State Univ.
24.	Soviet Feed - Livestock Economy: Projected Performance and Trade Implications	D.M. Schoonover ERS/USDA Washington, D.C.
25.	Techniques of Agricultural Supply Analysis	J.A. Seagraves N. C. State Univ.
26.	Estimation of Direct and Cross-Elasticities of Product Supply and Factor Demand	C.R. Shumway Texas A&M Univ.
27.	Production Capacity, Demand and Supply Responses, and Adjustment Needs	L. Tweeten Okla. State Univ.

NAL/CAIN ABSTRACTS

This section is a listing of books and articles on food models identified through a computerized search of the National Agriculture Library (NAL/CAIN) Abstracts. In most cases the items identified make reference to the development and use of a specific food related model.

1. Washington's apple industry: future tree numbers and production
Baritelle, John L.
Washington, D.C., U.S. Dep. Agr. Econ. Res. Serv.
TFS-189: 26-30 Nov. 1976

2. Supply response and marketing strategies for deciduous crops
Baritelle, John L.: Price, David W.
Lexington, Ky. American Agricultural Economics Association.
Amer. J. Agr. Econ. 56(2): 245-253 May 1974

3. A simulation of the fertilizer industry in the United States: with special emphasis on fertilizer distribution in Michigan
Bell, David M.: Henderson, Dennis R.: Perkins, George, R.
Mich. State Univ. Dep. Agr. Econ. Agr. Econ. Rep. 189, 148p Feb. 1972

4. An economic analysis of the United States fed beef industry
Bhagia, G. S.: Youde, James G.
Oreg. Agr. Exp. Sta. Spec Rep 374, 49p Oct. 1972

5. Agricultural development research priorities for the developing countries--a system simulation approach
Billingsley, Ray V.
Tex. Sgr. Exp. Sta. Tech. Art 9655, 13p Jan. 1972

6. Models for spatial agricultural development planning: by Fahmi K. Bishay
Rotterdam, University Press xv. 172p 1974 1973

7. The winter fresh tomato industry: A systems analysis/by John R. Brokker and James L. Pearson
U.S. Dept. of Agriculture, Economic Research Service
Washington: Economic Research Service, U.S. Dept. of Agriculture ii, 63p ill. 1976

8. Pesticide I: a general model to estimate regional and aggregate effects of pesticide withdrawls
Casey, James E.: Lacewell, Ronald D.
College Station, Tex. A&M Univ. Agr. Econ. Rural Socio. Agr. Econ. Program & Model Doc 73-3, 77p Sep 1973

9. Regional simulation model for spatially dispersed eonomic systems: a preliminary review with regard to dairy production
Ching, Chauncey T. K.: Frick, George E.
Penn State Univ. Dep. Agr. Econ. Rural Sociol AE&RS 93: 11-28

10. Economic projections using a behavioral model
Crom, Richard J.
Agr. Econ. Res. 24(1): 9-15 Jan. 1972

11. A dynamic price-output model of the beef and pork sectors
Crom, Richard
USDA Tech. Bull No. 1426 105p Sep. 1970

12. Effects of alternative marketing margins for beef and pork
Crom, Richard J.: Duewer, Lawrence A.
USDA Econ. Res. Serv. Agr. Econ. Rep. No. 243, 21p Aug 1973

13. Effects of alternative beef import policies on the beef and pork sectors
Duymovic, Andrew: Crom, Richard J.: Sullivan, James
USDA Econ. Res. Serv. Agr. Econ. Rep. 233, 24p Oct. 1972

14. Decision models for California turkey growers
Vernon R. Eidman: Harold O. Carter and Gerald W. Dean
Berkeley University of California, Division of Agricultural Science, California Agricultural Experiment Station 80p. illus. 1968

15. National and regional economic models of agriculture
Papers presented at a symposium held at Regina, June 15-16, 1972
Research Division, Economics Branch, Agriculture Canada
Ottawa: Economics Branch, Agriculture Canada 148p 1972

16. Application of an economic model for evaluating government program costs for rice
Grant W.R.
Tex. Agr. Exp. Sta. Dep. Agr. Econ. Sociol Dep. Tech. Rep. 69-1, 18 p July 1969

17. Locational analysis: An interregional econometric model of agriculture, mining, manufacturing and services
Curtis C. Harris and Frank E. Hopkins
Lexington, Mass., D.C. Heath & Co. xiv 303p tables 1972

18. U.S. national agricultural models conducted at Iowa State University
Heady, E. O.: Hall, H.H.
In econ. models & quant method dicis plan agriculture p. 360-368 1971

19. Spatial sector programming models in agriculture: 1st ed.
Heady, Earl Orel: Srivastava, Uma K.
Ames, Iowa State University Press xx 484p illus. 1975

20. A systems model of the U.S. rice industry
Holder, Jr. Shelby, H.: Shaw, Dale L.: Snyder, James C.
USDA, Tech. Bull 1453 86p Nov. 1971

21. A simulation model of farm sector social accounts with projections to 1980
Lins, David A.
Washington, D.C., U.S. Dep. Agr. Econ. Res. Serv. Tech. Bull. No. 1486 46p Dec. 1973

22. Simulated markets, farm structure, and agricultural policies
Lin, Steven A. Y.: Heady, Earl O.
Can J. Agr. Econ. 19(1): 55-65 Jul. 1971

23. A proposed simulation method for measuring structural change and rural development program impacts
MacMillan, James A.: Framingham, Charles F.: Tung Fu-lai
Ottawa, Canadian Agricultural Economics Society, Can J. Agr. Econ. 22(1): 26-41 Feb. 1974

24. The U.S. orange economy: demand and supply prospects 1973/74 to 1984/85
Matthews, Jimmy L.: Womack, Abner W.: Huang, Ben W.
Washington, D.C., U.S. Dep. Agr. Econ. Res. Serv. TFS-190: 39-51 Feb. 1974

25. A mass-energy economic model of a dairy farm
Misener, G.C.
Trans ASAE (Am Soc. Agri. Eng.) 19(2): 364-368, 371
Ref. Mar./Apr. 1976

26. Dynamic models of agricultural development with demand linkages
Mudahar, Mohinder S.
N. Y. (Cornell) Dep. Agr. Econ. Agr. Econ. Staff Pap.
No. 73-7 67p

27. Response of beef production in the South to changes in farm-level beef prices
Nix, James E.: Hubbard, John W.
Clemson, S. Car. Agr. Exp. Sta. Bulletin 579, 108p
Dec. 1974

28. Economic potential of the California trawl fishery
O'Rourke, Desmond
Amer. J. Agr. Econ. 54(4): 583-592 Nov. 1971

29. Excess capacity and adjustment potential in U.S. agriculture
Quance, Leroy: Tweeten, Luther
Agr. Econ. Res. 24(3): 57-66 July 1972

30. Government farm programs and commodity interaction: a simulation analysis
Ray, Daryll E.: Heady, Earl O.
Amer. J. Agr. Econ.: 578-590 Nov. 1972

31. Specification of a complete forecasting system for the fertilizer industry: development of an econometric forecasting model
Schink, George R.
East Lansing, Mich. State Univ. Dep. Agr. Econ. Agr. Econ. Rep. AE No. 259: 61-69 Dec. 1973

32. World trade in canned beef, 1962-1970
Simpson, James R.
Tex. Agr. Exp. Sta. Dep. Agr. Econ Social Dep. Inform. Rep. No. 73-7 77p May 1973

33. Alternative analyses of farm growth
Strickland, Jr., Roger P.
Washington, D.C., U.S. Dep. Agri. Agr. Econ. Res. 25(4): 99-104 Oct. 1973

34. An economic analysis of carryover policies for the United States wheat industry
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35. Reserve stocks of grain: A review of research/by Rodney L. Walker and Jerry Sharples
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36. Statistical decision theory in a macro simulation model: feed grain sector
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APPENDIX V

DISSERTATION ABSTRACTS

This section lists Ph.D. dissertations relating to food models, identified through a computerized search of the Dissertation Abstracts data banks.

1. A Recursive Programming Model of Regional Agricultural Development in Southern Brazil (1960-1970): An Application of Farm Size Decomposition. 219 Pages.

Ahn, Choong Yong (Ph.D. 1972 The Ohio State University)

2. Regional Agricultural Development Planning with Linear Programming and Simulation. 288 Pages.

Apedaile, Leonard Petry (Ph.D. 1968 Iowa State University)

3. Projections of Farm Employment in the United States Through 1980. 150 Pages.

Arcus, Peter Laurence (Ph.D. 1968 Iowa State University)

4. Beef Cattle Production. A Microeconomic Growth Curve Model With Special Reference to Sire Evaluation Under Tropical Conditions. 453 Pages.

Ariza-Nino, Edgar Julio (Ph.D. 1974 The University of Wisconsin-Madison)

5. A Projective Programming Information Model for the U.S. Beef and Pork Sectors. 121 Pages.

Aulaqi, Nasser Abdulla (Ph.D. 1974 The University of Nebraska-Lincoln)

6. Projections of Demand and Supply of Wheat and Rice in Pakistan, 1970-1985. 113 Pages.

Basit, Abdul (Ph.D. 1971 Washington State University)

7. A Multi-Sector Model for the Agricultural Socioeconomic System. Purnea District, Bihar, India. 240 Pages.

Biggs, Stephen Devon (Ph.D. 1974 University of California, Berkeley)

8. United States Agricultural Capacity: A General Equilibrium Model for 1965.

Bonnen, James Thomas (Ph.D. 1964 Harvard University)

9. Modeling Rice and Corn Markets in Thailand. 157 Pages.

Boonma, Chamnien (Ph.D. 1972 University of Illinois at Urbana-Champaign)

10. An Investigation Into Forecasting Planted Crop Acreages in the Short Run as a Quantitative Measurement Tool for Agribusiness Management. 149 Pages.

Borsdorf, Roe Everett (Ph.D. 1975 Kansas State University)

11. Developing a Multiperiod Linear Programming-Simulation Farm Firm Growth Model: Application To A Central Kentucky Beef Cattle Farm. 163 Pages.

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12. The Effect of Grain Price on the Profitability of Livestock Production-An Econometric Simulation. 229 Pages.

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13. A Model of Fertilizer Demand in the Asian Rice Economy: A Micro-Macro Analysis. 165 Pages.

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14. Market Simulation of Economic Behavior in the Meat-Products Industry. 319 Pages.

Duewer, Lawrence Alvin (Ph.D. 1965 Iowa State University)

15. A Model of the Monthly Structure of the United States Beef-Pork Economy. 137 Pages.

Elam, Thomas Earl (Ph.D. 1973 The University of Tennessee)

16. 1980 Beef Production Simulations. 81 Pages.

Finnie, Bruce Wendel (Ph.D. 1975 The University of Nebraska-Lincoln)

17. An Agricultural Land Use Model for New York State. 234 Pages.

Fox, Alan (Ph.D. 1973 Cornell University)

18. The Use of Wheat for Feed in the European Economic Community With Projections to 1975. 153 Pages.

Friend, Reed Eugene (Ph.D. 1970 University of Maryland)

19. An Interregional Intertemporal Activity Analysis Model of the United States Apple Industry. 186 Pages.

Fuchs, Hilarius William (Ph.D. 1973 The University of Connecticut)

20. A Non-State Model of the Beef and Pork Economy. 120 Pages.

Fuller, Wayne Arthur (Ph.D. 1959 Iowa State University)

21. Demand and Prices for Ohio Greenhouse Tomatoes and Projections of Prices to 1975. 103 Pages.

Garcha, Bikramjit Singh (Ph.D. 1963 The Ohio State University)

22. A Quarterly Econometric Model of the U.S. Dairy Subsector-1955-72. 137 Pages.

Goldman, Oscar (Ph.D. 1975 The Pennsylvania State University)

23. A Model for Estimating the Economic Effects of Agricultural Resource Development on Related Sectors of the Economy. 153 Pages.

Gordon, John Russell (Ph.D. 1970 The University of Wisconsin-Madison)

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24. An Economic Model for Evaluating Alternative Government Programs in Rice. 146 Pages.

Grant, Warren Ray (Ph.D. 1969 Texas A&M University)

25. Farm Policy Analysis Within A Farm Sector Model. 238 Pages.

Guebert, Steven Ray (Ph.D. 1973 The University of Wisconsin-Madison)

26. Growth Potential and Survival Capability of Southern Plains Dryland Farms: A Simulation Analysis Incorporating Multiple-Goal Decision-Making. 323 Pages.

Hatch, Roy Edward (Ph.D. 1973 Oklahoma State University)

27. A Dynamic Model Integrating Demand and Supply Relationships for Agricultural Water. Applied to Determining Optimal Intertemporal Allocation of Water in a Regional Water Project. 185 Pages.

Horowitz, Uri (Ph.D. 1974 Iowa State University)

28. Marketing of Canadian Wheat: An Economic Analysis With Projections for 1975 and 1980. 211 Pages.

Huff, Harry Bruce (Ph.D. 1969 Michigan State University)

29. An Analysis of Agricultural Production in Colombia With Projections for 1985. 212 Pages.

Hutchison, John Earl (Ph.D. 1972 University of Maryland)

30. Short-Term Forecasting Models for Average Monthly Prices of Wholesale Beef. 147 Pages.

Jones, Lonnie Lee (Ph.D. 1967 The Ohio State University)

31. A Simulation Analysis of Alternatvie Stabilization Schemes for Hog-Pork Prices. 258 Pages.

Kennedy, George Edward (Ph.D. 1973 Purdue University)

32. Projections of Product Supply and Factor Demand Under Structural Change for Korean Agriculture: A Systems Simulation Approach. 363 Pages.

Le, Jeung Han (Ph.D. 1975 Michigan State University)

33. Factor Demand in the United States Agriculture: Econometric Simulation. 203 Pages.

Lin, An-Yhi (Ph.D. 1967 Iowa State University)

34. A Computerized Model for Planning the Growth and Organization of Swine Farms. 191 Pages.

Lines, Allan Eugene (Ph.D. 1973 Purdue University)

35. Use of Multi-Period Linear Programming in Planning: An Empirical Model for the Farm Sector of South Viet-Nam. 177 Pages.

Luan, Chau Tam (Ph.D. 1965 University of Illinois at Urbana-Champaign)

36. Consumer Demand for Dairy Products in the United States, 1955-1969--Quarterly Model. 141 Pages.

Macdonald, Purificacion Ona (Ph.D. 1972 The Pennsylvania State University)

37. Regional Projections of Technological Change in American Agriculture to 1980. 247 Pages.

Maceachern, Gordon Albert (Ph.D. 1964 Purdue University)

38. Changes in the Grain and Livestock Economies of Italy With Projections to 1970 and 1975. 325 Pages.

Mangum, Fred Allen, Jr. (Ph.D. 1967 Michigan State University)

39. An Economic Model for Appraisal of Beef Production in the Midwest. 252 Pages.

Martin, Neil Robbins, Jr. (Ph.D. 1974 University of Illinois at Urbana-Champaign)

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40. Economic Development Potentials from Sector Demand Projections and Simulated Industry Alternatives, Eastern Shore, Virginia. 228 Pages.

Martin, Robert Jackson (Ph.D. 1974 Virginia Polytechnic Institute and State University)

41. A Systems Model of the Cattle Economy-A Guyana Application. 359 Pages.

May, Ralph Dewel (Ph.D. 1975 Purdue University)

42. Simulation of the Cattle-Claves Sub-Sector in a Developed Economy With Special Reference to the Canadian Cattle Herd. 414 Pages.

Meek, John James (Ph.D. 1975 Michigan State University)

43. An Econometric Model of the California Dairy Industry. 330 Pages.

Milligan, Robert Alexander (Ph.D. 1975 University of California, Davis)

44. An Input-output Model for the Texas Economy With Emphasis on Agriculture. 178 Pages.

Mustafa, Gholam (Ph.D. 1971 Texas A&M University)

45. Demand for Feed Wheat by Nations With Projections to 1980. 214 Pages.

Muermans, Luc Simon (Ph.D. 1971 The University of Nebraska-Lincoln)

46. Application of the Econometric Model. Distributed Lag. To Forecasting Slaughter Cattle Price. 184 Pages.

Myers, Walter Mcilroy (Ph.D. 1973 Oklahoma State University)

47. Beef Production in the South: Model Development and Economic Appraisal of Beef Supply Response. 267 Pages.

Nix, James Elbert (Ph.D. 1974 Clemson University)

48. Quarterly Structure of the Argentine Beef Cattle Economy: A Short Run Model, 1960-1970. 212 Pages.

Nores, Gustava Adolfo (Ph.D. 1972 Purdue University)

49. A Programming Model for the Planning of Agricultural Economy of Thailand. 203 Pages.

Onchandra, Tongroj (Ph.D. 1969 University of Illinois at Urbana-Champaign)

50. Quantitative Analysis of Applying Random Coefficient Regression Model to the Short-Run Fluctuations for Hogs. 130 Pages.

Ong, Kao-Twan (Ph.D. 1973 University of Illinois at Urbana-Champaign)

51. An Econometric Model for Analyzing Agrentine Beef Export Potentials. 132 Pages.

Otrera, Wylian Rolando (Ph.D. 1966 Texas A&M University)

52. Livestock and Crop Production Patterns in Uttar Pradesh, India and Projections of Alternative Livestock Development Possibilities. 147 Pages.

Pandey, Roop Narayan (Ph.D. 1973 University of Illinois at Urabana-Champaign)

53. A Recursive Model of the United States Domestic Soybean Market. 160 Pages.

Paulino, Leonardo A. (Ph.D. 1966 Michigan State University)

54. An Aggregative Income and Wealth Model for the United States Farm Sector: Its Description and Application to Policy Analysis. 373 Pages.

Penson, John Bartram, Jr. (Ph.D. 1973 University of Illinois at Urbana-Champaign)

55. A Farm Level Econometric Model of the United States Apple Industry: Applications to Forecasting and Analysing Policy Issues. 327 Pages.

Piggott, Ronald Roy (Ph.D. 1974 Cornell University)

56. A Simulation Analysis of Policies for the Northern Colombia Beef Cattle Industry. 427 Pages.

Posada, Alvaro (Ph.D. 1974 Michigan State University)

57. A Quarterly Simulation Model of the Livestock and Poultry Subsectors for Use in Outlook and Price Analysis. 257 Pages.

Rahn, Allan Paul (Ph.D. 1973 Iowa State University)

58. A Structural Analysis and Linear Programming Within an Input-output Model Emphasizing Agriculture in India. 212 Pages.

Ramachandran, Marudarajan (Ph.D. 1963 Iowa State University)

59. An Economic Model for Establishing Priorities for Agricultural Research and a Test for the Brazilian Economy. 252 Pages.

Ramalno De Castro, Jose Prazeres (Ph.D. 1974 Purdue University)

60. An Econometric Simulation Model of the United States Agriculture With Commodity Submodels. (Volumes I and II). 612 Pages.

Ray, Daryll Eugene (Ph.D. 1971 Iowa State University)

61. Iran. Long Term Projection of Demand for and Supply of Major Agricultural Commodities for 1970, 1975, 1980, and 1985. 261 Pages.

Ronaghy, Hassan Ali (Ph.D. 1969 The University of Wisconsin-Madison)

62. Econometric Projections of Vegetable Crops, New York State, United States and Other Selected Regions. 291 Pages.

SAAD, Abdel-Hamid Youssef (Ph.D. 1969 Cornell University)

63. An Econometric Simulation Model of Wisconsin's Dairy Industry. 267 Pages.

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64. Estimating Normative Supply Schedules: An Alternative Model for Beef Cattle and Hogs in Northeast Missouri. 244 Pages.

Sanderson, John Timothy (Ph.D. 1969 University of Missouri-Columbia)

65. A Programming Model for Determination of Agricultural Investment Policy. Including Investment in Technological Growth. 179 Pages.

Schaefer, John Carroll (Ph.D. 1974 Stanford University)

66. Application of Input-Output Analysis to a Regional Model Stressing Agriculture.

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67. A Forecasting - Programming Method for Placement-Sales Decisions for a Beef Feedlot. 231 Pages.

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68. Empirical Decision Rules for Agricultural Policy: A Simulation Analysis of the Feed Grain Program. 358 Pages.

Shechter, Mordechai (Ph.D. 1968 Iowa State University)

69. Narrowing Taiwan's Per Capita Farm/Nonfarm Income Gap Via Increased Agricultural Production and Guaranteed Prices: Projections and Analysis, 1973-1984. 240 Pages.

Shen, Raphael (Ph.D. 1975 Michigan State University)

70. Policy Model for Simulation of Development Plans: Vietnam Agricultrue, 1970-1978. 244 Pages.

Smith, Tonas Arthur (Ph.D. 1973 The George Washington University)

71. A Spatial Equilibrium Model of the Beef Industry in the United States. 272 Pages.

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72. The DA Zhai Model in Chinese Agriculture, 1964-1974. 594 Pages.

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73. A Quadratic Programming Model of United States Agriculture in 1980: Theory and Application. 304 Pages.

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74. Simulation. Decomposition and Control of a Multi-Frequency Dynamic System: The United States Hog Production Cycle. 201 Pages.

Talpaz, Hovav (Ph.D. 1973 Michigan State University)

75. A Simulation Analysis of the Economic Structure of United States Agriculture. 142 Pages.

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76. An Econometric Analysis and Forecasting Model for Beef. 178 Pages.

Uvacek, Edward, Jr. (Ph.D 1967 Texas A&M University)

77. Analysis of Demand for Wheat in the European Economic Community with Projections to 1970 and 1975. 144 Pages.

Vigen, James Walter (Ph.D. 1965 The Ohio State University)

78. Subsector Demands for Beef: Analyses and Projections. 165 Pages.

Wallace, Arthur, Jr. (Ph.D. 1964 Oklahoma State University)

79. An Interregional Activity Analysis Model of the Pennsylvania Milk Manufacturing Industry. 130 Pages.

Wick, Pascal Jean (Ph.D. 1971 The Pennsylvania State University)

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80. Structural Projections of the Wisconsin Dairy Industry's Production Sector to 1980. 352 Pages.

Willett, Gayle Steven (Ph.D. 1971 The University of Wisconsin-Madison)

81. An Econometric Model for the Foreign Trade Sector of India: 1960/61-1971/72. 203 Pages.

Yadav, Ram Prakash (Ph.D. 1975 Cornell University)

MODEL PANEL PARTICIPANTS

Purpose of Meeting

GAO invited several experts on agricultural economics and food modeling to participate in a half day seminar on November 29, 1976, to discuss the following issues: (1) state of the art on food and agricultural models, (2) analysis of known food and agricultural models, and (3) the types of output models can yield to aid policy analysis.

Discussion

Panel members were in general agreement that the state of models has progressed substantially in recent years and that model proliferation has (1) made knowledge about existing known models difficult, (2) led to poor and inadequate documentation of models, and (3) created a need to educate decisionmakers about models and to establish some type of institutional mechanism for keeping track of models.

The panel agreed that asking precise, well structured questions of the major modelers would help to evaluate the potential models have for food policy analysis. They also agreed that current models are sophisticated enough to allow meaningful policy analysis.

Panel Members

Dr. Leroy Quance, USDA

Dr. Luther Tweeten, Oklahoma State University

Graham T. T. Molitor, Director of Government Relations, General Mills

Dr. John Richardson, American University

R. C. Shreckergost, Central Intelligence Agency