Using the Microcomputer to Build and Operate a Grain, Oilseeds, and Livestock (GOL) Simulation Model

by

John Wainio, Karen Liu, and Vernon Roningen

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Abstract: The advent of the microcomputer has changed the environment for the economic model builder and potential user of these models. It is now possible to have large economic models operating within spreadsheets. This approach has proven to be far cheaper, simpler, and quicker to use than any mainframe modeling system.

Most modeling activities have, in the past, required complex computer programs or simulation packages housed on a mainframe. While a mainframe modeling system is flexible and powerful, any large modeling activity on a mainframe computer tends to be expensive and a large consumer of economists' time and attention. The turnaround time, alone, incurred between submission of a job and eventual possession of a hardcopy of the results can be a long and frustrating process. The diagnostics available should your job fail to run are often incomplete or hard to interpret. The microcomputer offers an ideal solution to some of the more common problems associated with modeling on the mainframe, while providing added benefits in such areas as cost, convenience, and flexibility. It removes the "black box" aspect of modeling on the mainframe and is thus an ideal teaching tool for the classroom. It also makes it possible to distribute workable models more widely to commodity analysts, extension professionals, and other interested parties who do not have access to a mainframe but do possess a micro.

This paper illustrates one example of how switching a particular modeling activity from the mainframe to the microcomputer was accomplished. The focus is on outlining the use of the microcomputer to prepare and operate a country component of the USDA/ERS world grain, oilseeds, and livestock (GOL) model within a spreadsheet. We emphasize, however, that this approach is applicable to other types of modeling systems as well. All it takes to put one of these models to use is some knowledge of how to use a spreadsheet. The process of manipulating the spreadsheets in order to modify or simulate the model is largely automated through the use of a series of programs written in IBM PC BASIC. Therefore, an IBM or IBM compatible microcomputer with an MS/DOS operating system, SuperCalc3, and BASIC are all that is required to put one of these models to use. All of the spreadsheets and a complete set of programs needed to operate a GOL country model can fit on one floppy disk.

The paper contains three parts. The first part demonstrates the overall framework developed to accomodate the coefficients and data of each GOL country/region model in spreadsheets. The second part provides an explanation of the methods used to operate and maintain these models on the microcomputer. The third part discusses some of the uses of these models and speculates on some further applications of integrated spreadsheet technology in the model building arena.

The Microcomputer GOL Framework

The world GOL trade model is an annual simulation model designed to provide mid- to long-term projections of world food supply and demand under alternative world economic assumptions and to analyze the impact of major international economic and policy changes on U.S. and world agricultural trade. The world model consists of 26 country or regional models plus a rest of world component and includes 20 major agricultural commodities whose trade is of interest to the United States. Not every country/region model contains all twenty commodities. Inclusion of a commodity in an individual model was based on that country or region being a significant producer, consumer, importer, or exporter of that commodity. Table 1 contains a grid identifying, with a "1", which commodities are contained in each of the 26 models. Those cells in the grid containing a "0" make up the rest of world component for each commodity.

The GOL model was originally created and maintained in a simulation system run on a large mainframe computer. At the same time, extensive use was made of the microcomputer to enter data and models into the mainframe computer and to manipulate, aggregate, and analyze the simulation results produced on the mainframe. Experimentation with "program driven" spreadsheets used in analyzing these results led to the development of country components of the GOL model within the spreadsheets themselves. This meant that model input and preparation, simulation, and analysis of simulation results could be done entirely in the spreadsheets.

In the current microcomputer version of GOL any country or regional component can be a simple standard model or a detailed standard model. A simple standard model has fewer equations with far fewer cross-commodity links than a detailed standard model and uses world prices instead of domestic prices in the supply and demand equations. A simple standard model contains four groups of equations: (1) supply equations, (2) demand equation, (3) net trade equations, and (4) price equations. Supply is defined as production plus beginning stocks, demand is defined as consumption plus ending stocks, and net trade is the difference between supply and demand.

Total quantity supplied is generally specified as a function of current and lagged real prices, current and lagged cross commodity real prices, a time trend, and a supply shift variable. A value of "1" for the shift variable denotes "in trend". The shift variable would normally remain set equal to one over projection periods, but it can be given other values; for example, to simulate the effect of unusual weather. Total demand for a commodity is calculated as the quantity of per capita demand multiplied by population. Per capita demand for a commodity is specified as a function of current and lagged real prices, current and lagged cross commodity real prices, and real income per capita. The general functional form of the supply and demand equations in GOL is non-linear with constant elasticities over all price ranges. An equation intercept is calculated using base year prices and quantities. As a result, each supply and demand equation carries, embedded in the intercept, information about initial base year conditions. Exceptions include the supply equations for meals and oils which are set equal to crushing yields times the quantities crushed. Demand for soybeans and oilseeds is primarily for crushing into oils and meals. Both the input prices for oilseeds and the ouput prices for meals and oils can affect the quantity demanded for crushing. Thus the demand for soybeans and oilseeds is specified as a function of the ratio of the weighted output prices to the input price. Crushing demand also depends on a time trend, which serves as a proxy for changes in crushing capacity.

Each country model allows trade to be limited by export and/or import quotas. A net trade equation generally sets net trade equal to the difference between quantity supplied and quantity demanded. If a trade quota is binding, then an additional equation estimating the domestic market clearing price is required. In this case, the internal price is raised or lowered to clear the domestic market. For additional information on the structure of a simple standard GOL country model, see Liu and Roningen.

Data requirements for building a simple standard country model include supply, demand, and trade quantities, prices, income, and population. Parameter requirements include supply and demand own and cross price elasticities, income elasticities, and growth rates. All of the data and parameters for each country/region model are contained in files saved in Supercalc3 (Release 2) spreadsheets. Briefly, a SuperCalc3 (SC3) spreadsheet consists of a two-dimensional grid containing cells at the intersection of each row and column. Information and data are entered into these cells. Individual cells can then be interrelated using logical commands and mathematical functions. An integrated graphics package is available to aid the user in interpreting and presenting the data. Three file types are contained in these spreadsheets: the model file, the input data files, and the output data files. 1/

The model file:

The model file is contained in a spreadsheet of dimensions 30 rows x 50 columns. Each of the 27 country/region GOL model files is made up of four sections or grids. The first grid contains all of the price elasticities and growth rates found in the commodity supply equations. It also contains a listing of the codes used to abbreviate the 20 commodities included in the world GOL model. Similarly, the second grid contains the price and income elasticities used in the commodity demand equations. The third grid contains all of the equation intercepts as well as the base year data used in calculating these intercepts. It also contains base year information about any import or export quotas in the model as well as the base year values of the supply shift variables. The final grid contains the model equations. The equations are written in the form of SC3 formulas with the individual variables and parameters denoted by their respective cell references in the model file spreadsheet.

The input data files:

There are four distinct forms of input data files. One contains the historical time series data on quantities supplied and demanded while the other three contain historical data as well as time series data covering the entire forecast period for all the exogenous variables. The supply and demand data are contained in individual commodity spreadsheets. For each commodity included in a country component, there exists a spreadsheet containing supply

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1/ See Roningen, Wainio, and Liu for a more detailed documentaion of the data files and computer programs used in the microcomputer version of the GOL.

Table 1: Summary matrix of GOL country/regions and commodities

(1 - model equations exist, 0 - model equations do not exist)

World Grain, Oilseeds, and Livestock (GOL) Model		1 US	2 CN	3 EC	4 WE	5 JP	6 AZ	7 SF	8 EE	9 SV	10 CH	11 MX	12 CA	13 BZ	14 AR	15 VE	16 LA	17 AF	18 EG	19 ME	20 ND	21 OS	22 DO	23 TH	24 SA	25 EA	26 OA	27 RW	Country/reg. per commod. GOL	Country/reg. per commod. RW
1 Beef & Veal	BF	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	15	12
2 Pork	PK	1	1	1	1	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	12	15
3 Mutton & Lamb	ML	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	14	13
4 Poultry-Meat	PM	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	14	13
5 Poultry-Eggs	PE	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	13	14
6 Wheat	WH	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	24	3
7 Corn	CN	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	1	1	1	0	1	20	7
8 Other Coarse Grains	CG	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	0	1	0	1	1	0	0	0	0	1	0	1	16	11
9 Rice	RI	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	22	5
10 Soybeans	SB	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	14	13
11 Other Oilseeds	OS	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	1	0	1	1	1	1	0	1	0	0	1	18	9
12 Soymeal	SM	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	1	0	0	0	1	1	0	0	1	16	11
13 Soyoil	SO	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	19	8
14 Other Meals	OM	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	1	1	0	1	1	1	1	0	1	0	0	1	19	8
15 Other Oils	OO	1	1	1	0	1	1	0	-1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	0	1	1	0	1	20	7
16 Dairy-Butter	DB	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	9	18
17 Dairy-Cheese	DC	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	13	14
18 Dairy-Other Products	DO	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	14	13
19 Cotton	CT	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	22	5
20 Sugar	SU	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	25	2
Commodities per country/region		20	15	20	19	19	12	6	20	20	13	15	8	17	14	9	10	10	6	14	11	7	7	5	9	11	2	20	339	201

GOL Countries/Regions

Developed Countries (DC)

US United States
CN Canada
EC European Community (10)
WE Western Europe (other)
JP Japan
AZ Australia & New Zealand
SF South Africa

Subsaharan Africa & Middle East (ME)

AF Africa (Subsaharan)
EG Egypt
ME Middle East & North Africa

Centrally Planned Countries (CP)

EE Eastern Europe
SV Soviet Union
CH China (Peoples' Republic)

Asia (AS)

ND India
OS Other South Asia
DO Indonesia
TH Thailand
SA Southeast Asia (other)
EA East Asia
OA Other Asia

Latin America (LA)

MX Mexico
CA Central America and Caribbean
BZ Brazil
AR Argentina
VE Venezuela
LA Other South America

RW Rest of World

World (WD)

and demand data for that country. Thus there are 339 commodity spreadsheets in the GOL world model (or one for every cell containing a "1" in the country/commodity grid of table 1). Each of these commodity spreadsheets has a seven-character name, beginning with the letters GOL. The next two characters refer to the country/region code; the last two designate the commodity code. Because an effort was made to build in as much standardization as possible in the GOL model, there exists one template that can be overlaid over any of these 339 spreadsheets. This template contains headings for the rows and columns as well as a number of formulas and specifications for graphs. The use of templates on the microcomputer saves space on a floppy or hard disk and can eliminate much of the cost of inputting repetitive data and information.

In addition to the input data found in the commodity spreadsheets, each country component contains three other spreadsheets containing input data files. The first contains income and population data starting in 1970 and projected to the year 2000. Population data and projections were prepared by the U.S. Bureau of Census. Income indexes for GOL regions are obtained from various issues of the International Financial Statistics published by the International Monetary Fund. The second spreadsheet contains the values of the shift variables and any export and/or import quotas imposed in the model. The third contains world price data for each commodity in the model starting in 1970 and projected to the year 2000. Because little data is available on the domestic prices of GOL commodities in many of the country/regions, a representative price of each commodity in the world is used as the internal price in each model (e.g., a U.S. FOB Gulf price for wheat, a Bangkok FOB price for rice, etc.). These prices are from various sources, including the International Monetary Fund, the Food and Agricultural Organization, and the U.S. Department of Agriculture. They were deflated using the World Bank's CPI deflator for the major industrial countries, 1980 base. Assumptions were then made about the future time paths of each price.

The output data files

A simple GOL model simulates total supply, total demand, net trade, and internal prices. The simulation output is stored in output data found in the individual commodity spreadsheets, the same spreadsheets which contain the input data files with the historical supply and demand data. Saving these input data files and the output files together allows the analyst to quickly compare actual and simulated values, using the integrated SC3 graphics package. One would hope that the results of a historical simulation match the behavior of the real world, particularly in being able to duplicate turning points. At the same time, one would like some quantitative measure of how closely each endogenous variable tracks its corresponding historical data series. Formulas contained in the template allow one to calculate simulation goodness of fit statistics such as the root-mean-square percent error statistic or Theil's inequality coefficient, broken down into its characteristic sources.

The output files also contain space in which to save simulations made under alternative assumptions. By changing parameter values or letting exogenous variables follow different time paths one can examine and compare what might have taken place as a result events or policies. Should the analyst wish to generate alternative forecasts conditional on a different set of assumptions about the future time paths of the exogenous variables, the results may be saved in the same spreadsheets and compared on the same graph.

The Mechanics of Operating and Maintaining a Microcomputer GOL Country Model

An integral part of the microcomputer version of a GOL country model is a set of 11 BASIC programs which automate most tasks of model creation, updating, and output presentation. The main feature of these programs is the automatic creation of a group of SC3 execute files. The use of execute files to manipulate a micro GOL country model allows a series of spreadsheet commands to be performed with only a minimum of keyboard entry. Each line in an execute file contains the exact characters that would be entered on the keyboard in order to execute a specific command in SC3. When an execute file is run, these commands are carried out in sequence, thus automating such functions as the loading of data or templates, the calculation of formulas, and the saving of output.

Another feature associated with a GOL country model involves the use of batch files, each of which contains a series of commands that DOS executes one at a time. Batch files enable the mechanical tasks of getting into and out of BASIC and SC3 in order to run the various programs and the execute files to also be automated. This is possible because of the option existing in both BASIC and SC3 which allows the user to specify the name of a program or execute file directly when loading BASIC or SC3 from DOS. When using this option, both BASIC and SC3 will, once loaded, automatically run the designated program or execute file. Starting the execution of a batch file is done in DOS by merely typing a drive specifier and the name of the file, e.g. B:(filename).

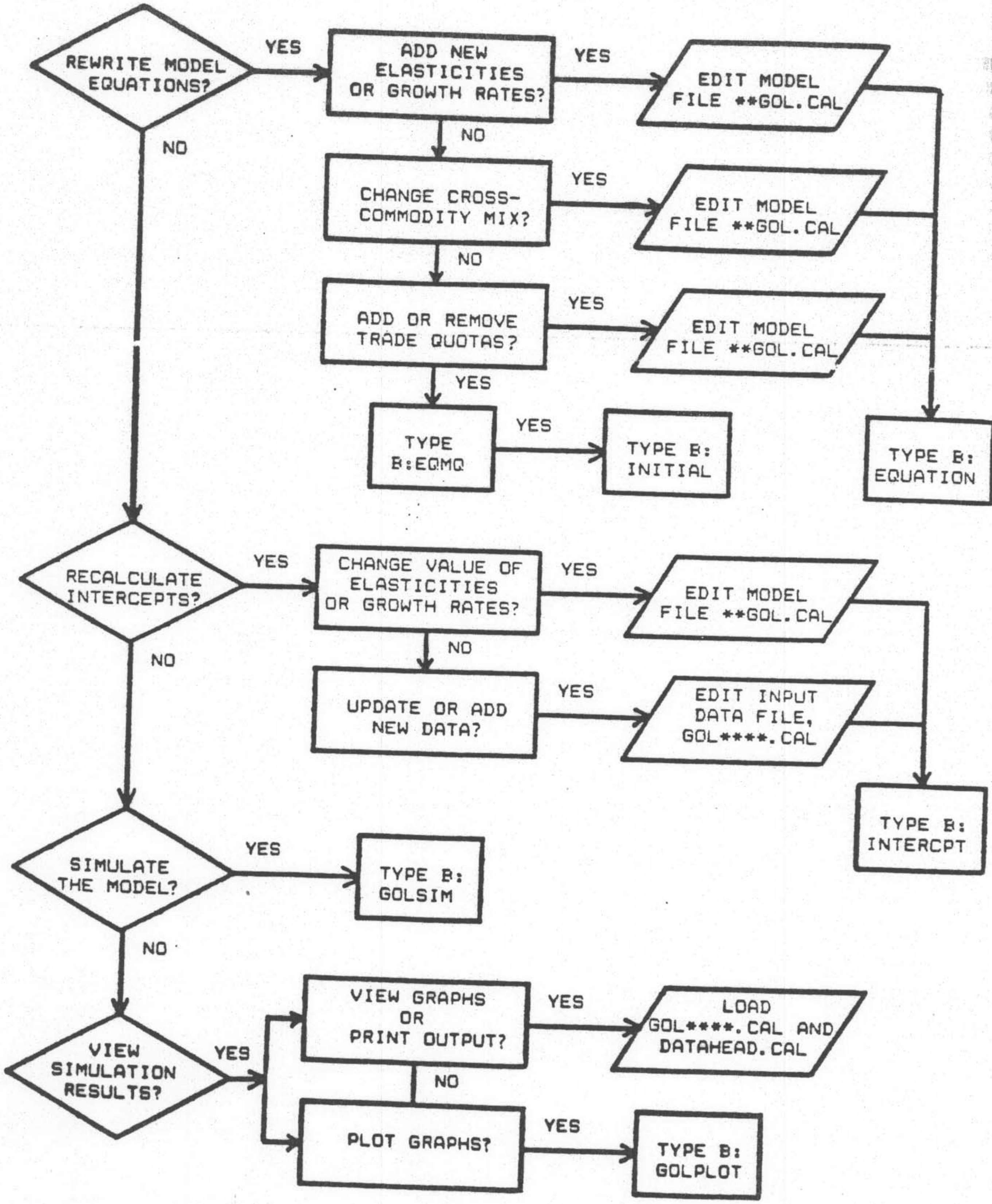
As an example of a model including all commodities, a directory of all of the files needed to operate the U.S. model as a standalone component on the microcomputer are listed in table 2. All of the SC3 spreadsheets have the .CAL extension after the filename. The first spreadsheet listed in table 2 contains the U.S. model file with the model equation parameters, base year data, and the equation formulas. All of the individual country model filenames begin with the two character country code, followed by the letters GOL. The next 20 files listed are the individual commodity spreadsheets containing the input and output data files for the 20 commodities found in the U.S. model. The template that goes with these files (containing row and column headings, formulas, and graphs) is contained in the spreadsheet named DATAHEAD.CAL. The remainder of the files listed in table 2 include the spreadsheets containing exogenous data as well as the Batch files (.BAT extension) and BASIC programs (.BAS) that drive the model.

The BASIC programs are designed to automate a number of tasks associated with changing as well as simulating the model. Should the user desire to change the specification of an equation or to add an equation, a set of programs exists to automatically write or rewrite the equations. Similarly, programs exist to automatically calculate equation intercepts and to impose and calculate trade bounds in the form of quotas as well as calculate a market clearing domestic price should the quota be a binding one. Programs are run by executing an associated batch file. Figure 1 illustrates the steps which precede execution of a batch file and the associated BASIC programs. The diamonds on the left side of the diagram represent the various options available to the user of a GOL model. Beginning with the option to rewrite the model equations, arrows lead either to eventual execution of a batch file (started by typing the statement found in the squares) or to the next option.

Table 2: Directory of files for the microcomputer version of the USGOL model

FILES	DESCRIPTION
USGOL .CAL	USGOL model file
GOLUSBF .CAL	Commodity spreadsheets containing input and output data files
GOLUSPK .CAL	
GOLUSML .CAL	
GOLUSPM .CAL	
GOLUSPE .CAL	
GOLUSWH .CAL	
GOLUSCN .CAL	
GOLUSCG .CAL	
GOLUSRI .CAL	
GOLUSSB .CAL	
GOLUSOS .CAL	
GOLUSSM .CAL	
GOLUSSO .CAL	
GOLUSOM .CAL	
GOLUSOO .CAL	
GOLUSDB .CAL	
GOLUSDC .CAL	
GOLUSDO .CAL	
GOLUSCT .CAL	
GOLUSSU .CAL	
DATAHEAD.CAL	Commodity spreadsheet template
WDPT .CAL	World price spreadsheet
USINCPOP.CAL	U.S. income and population spreadsheet
USSFEQMQ.CAL	Shift variable and trade quota spreadsheets
SFEQMQ .CAL	
QUOTACAL.CAL	Spreadsheet containing trade quota formulas
EQUATION.BAT	Equation-writing programs
BEGINEQ .BAS	
EQUATION.BAS	
EQMQ .BAT	Trade quota programs
EQMQ1 .BAS	
EQMQ2 .BAS	
INITIAL .BAT	Model initializing programs
INITIAL1.BAS	
INITIAL2.BAS	
INTERCPT.BAT	Intercept calculating programs
INTERCP1.BAS	
INTERCP2.BAS	
GOLSIM .BAT	Model simulation programs
GOLSIM .BAS	
GOLPLOT .BAT	Programs and execute files to automatically plot commodity graphs
GOLPLOT .BAS	
EQ .XQT	
MQ .XQT	
WDGOL .PRN	Matrix of GOL country/regions and commodities

Figure 1: Steps involved in modifying and simulating a microcomputer version of a GOL country/region model



The Use of the Model

The microcomputer version of the GOL model has been used in a number of projects including, most recently, the world food study and the baseline forecasting exercise. This section presents sample output generated using a simple version of the Canadian GOL country model. The structure of this model and the value of the coefficients can be found in Liu and Roningen.

A base run simulation of the Canadian GOL model was generated for the period from 1971 to 1995 using 1980 as the base year. Table 3 provides the root mean square percent errors for the Canadian beef and wheat equations. The actual values for Canadian beef and wheat supply and demand for the 1971 to 1985 period as well as the simulated values for 1971 through 1995 are plotted in figures 2a-2b and 3a-3b. Note that the model reproduces the general trend in Canadian wheat supply but fails to predict any of the turning points. The demand equation does a slightly better job of reproducing the historical data, but fails to pick up the downturn in Canadian wheat demand in the early 1980's. The beef equations fail to capture the sharp increases in supply and demand which took place in the mid to late sixties. Because of the simplicity of these equations we would obviously not want to rely on them for forecasting, although we can see that in three of the four equations the RMS percent errors are considerably lower in the ex post forecast than in the historical simulation.

Table 3: Root Mean Square Percent Errors for the Canadian Model Beef and Wheat Supply and Demand Equations

Commodity	Variable	Historical Simulation (1971-1979) 1/	Ex post Forecast (1981-1985)
Beef	Supply	18.2	4.3
	Demand	11.6	9.1
Wheat	Supply	16.9	10.4
	Demand	16.3	31.9

1/ Because the equations were initialized using 1980 prices and quantities, 1980 values are not used in calculating the RMS percent error statistics.

The actual and base simulation values for Canadian wheat supply are once again plotted in figure 4, along with values from an alternative simulation. In this case, shift variables were added to the supply equation based on yield values for the previous ten years of historical data. This ten year pattern of yields was then imposed on the next ten years to produce the alternative forecast. While the results are trivial, generating this sort of example and running an alternative twenty year simulation of the model took less than five minutes on an IBM-AT. It is included to demonstrate the speed with which alternative scenarios can be produced on the microcomputer.

Figure 2a: Actual and simulated values of Canadian wheat supply.

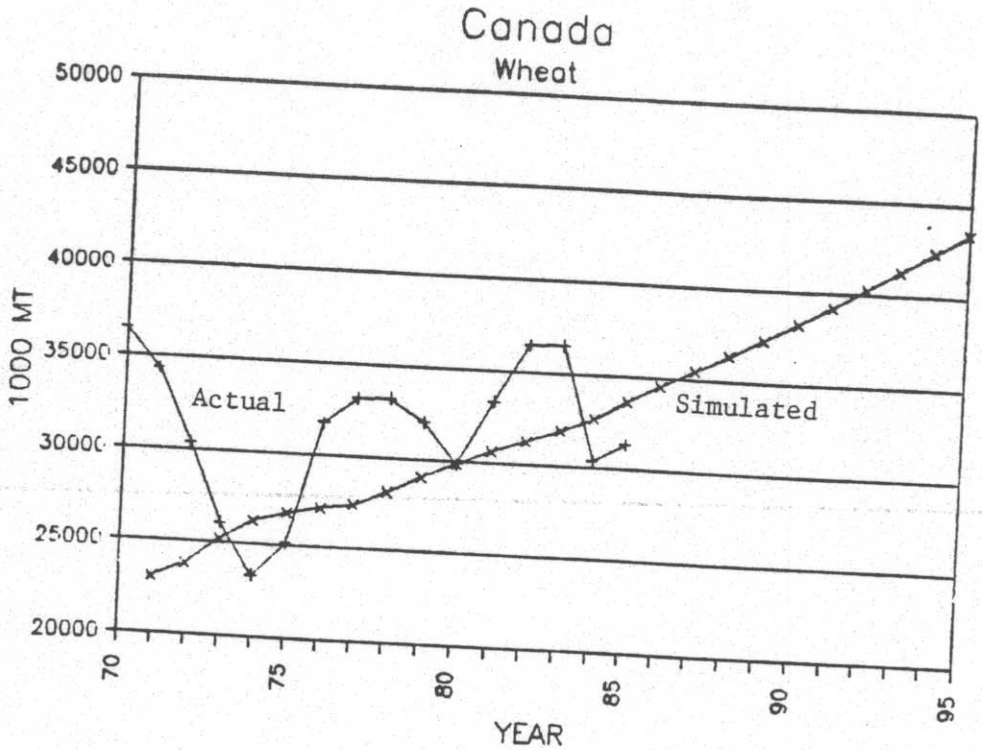


Figure 2b: Actual and simulated values of Canadian wheat demand.

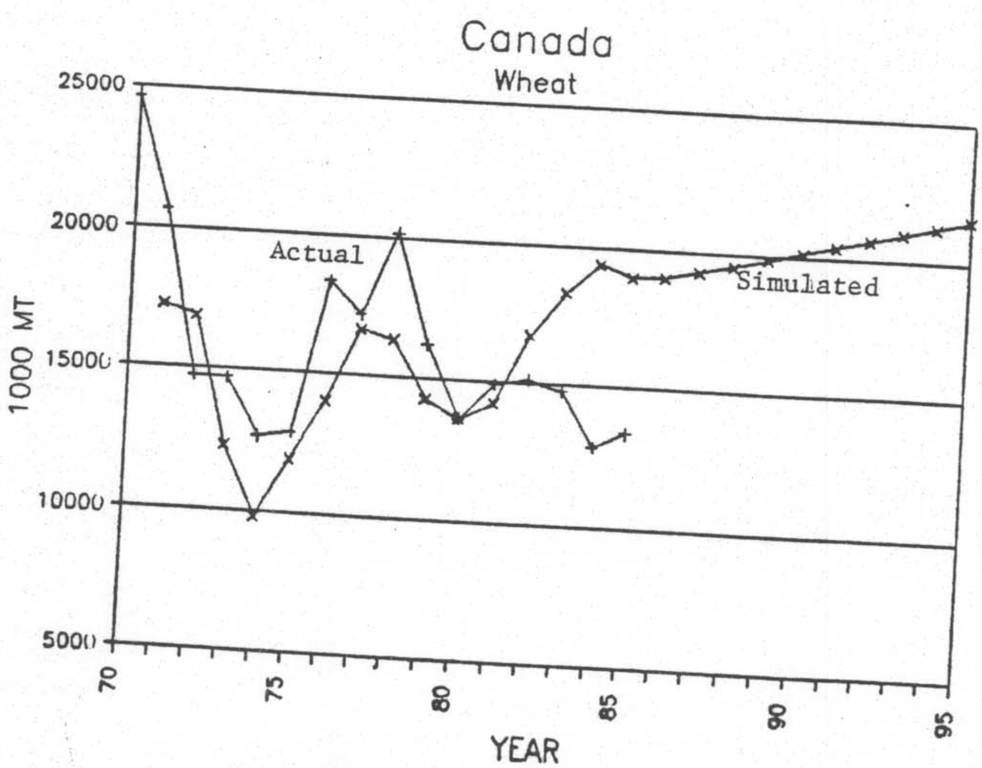


Figure 3a: Actual and simulated values of Canadian beef supply.

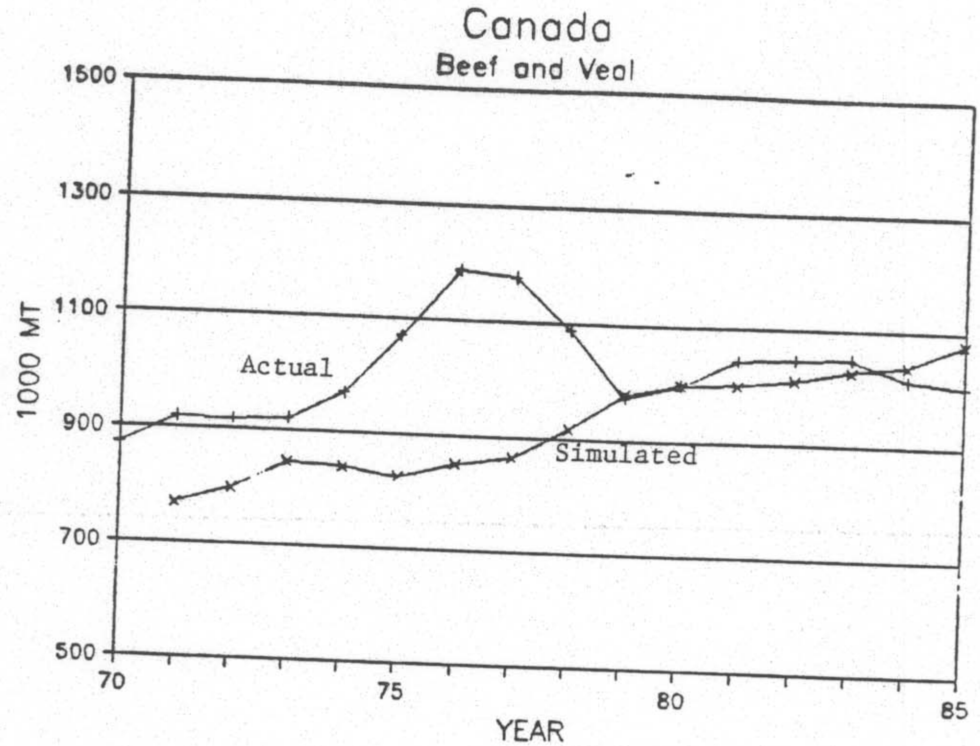


Figure 3b: Actual and simulated values of Canadian beef demand.

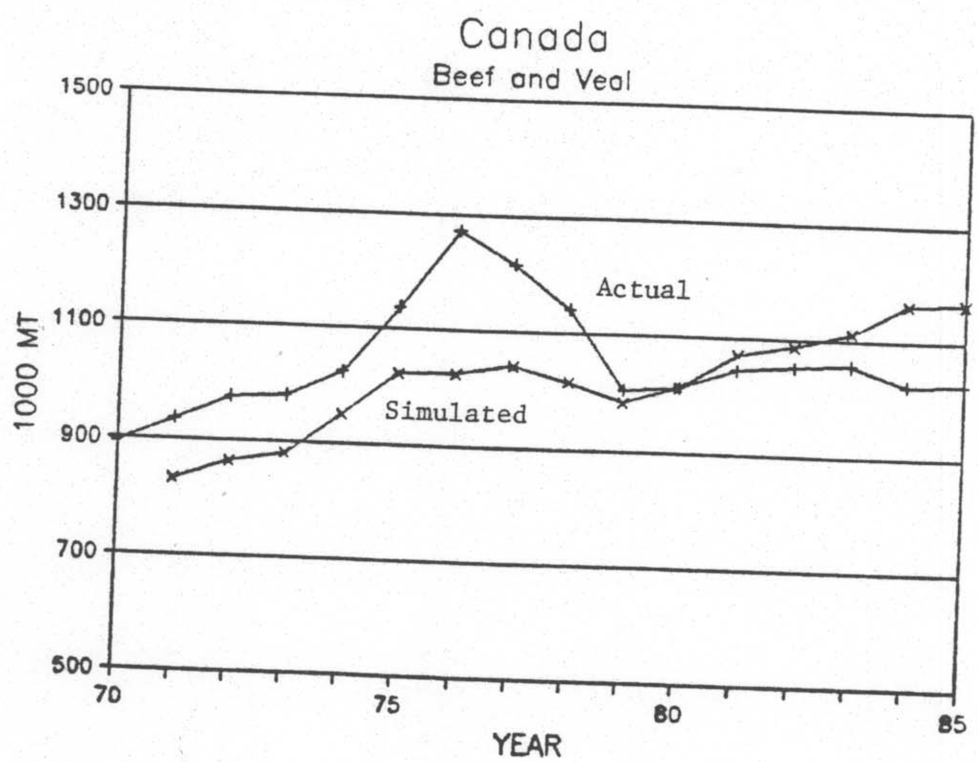
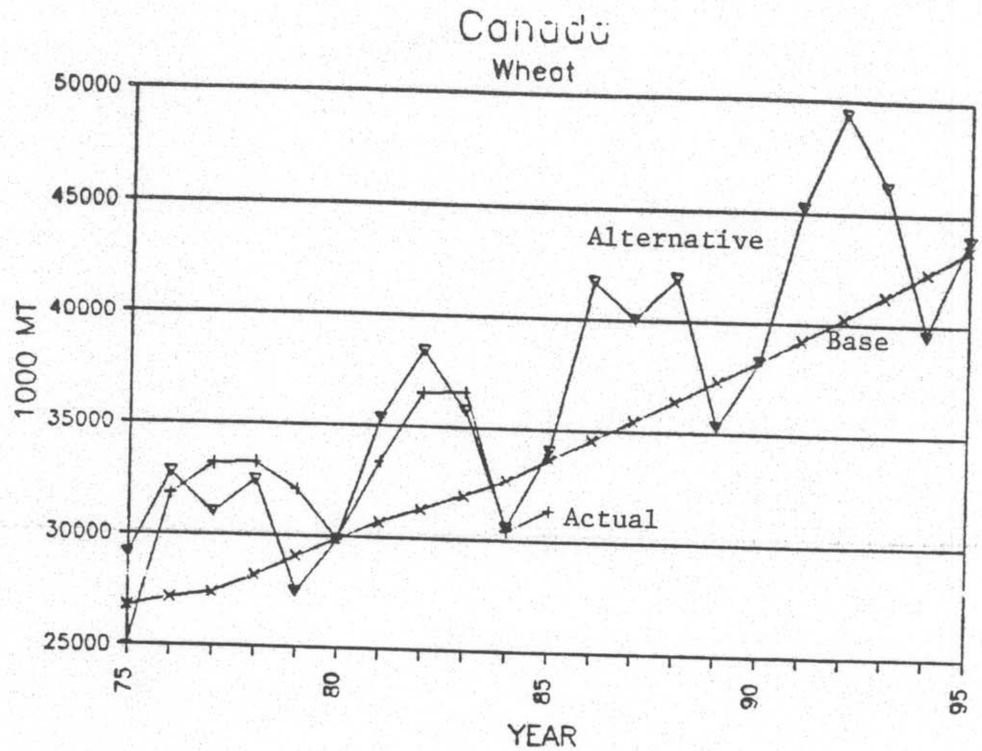


Figure 4: Base and alternative forecasts of Canadian wheat supply.



IV. Concluding Remarks

The advent of the microcomputer along with powerful but "user friendly" spreadsheet technologies has drastically changed the environment for the economic model builder. It is now possible for the model builder to have large economic models operating within a simple spreadsheet. This approach has proven to be far cheaper, simpler, and most importantly, quicker to use than any mainframe modeling system. In addition, it gives the analyst greater control over the process of model building and operation than previous systems afforded. Since the models and simulation results are contained in spreadsheets, it is easy to create additional spreadsheets of derived calculations, aggregate solutions, and graphics of model output. This feature, relying on integrated spreadsheet technology, makes models on the microcomputer available to a much larger cross-section of the agricultural community.

It is not difficult to see the advantages of the microcomputer to the model builder as well as to the model user. This arises from the fact that model building is very much an art. During the econometric estimation phase a number of hypothetical relationships are tested against the data until some statistically acceptable solution is generated. Once the model has been estimated, the often larger task awaits of evaluating and validating it in a simulation context. With a multi-equation simulation model, even if all of the equations fit the data well and are statistically significant, because the dynamic structure of the model is far richer than that of any of the individual equatiions of which it is formed, we have no guarentee that the model as a whole when simulated will reproduce the historical series closely. It is entirely possible for an equation to have a good statistical fit but a poor simulation fit. Structural instability may have been built into a model that wouldn't appear in any of the individual equations, but would show up when the equations were combined and solved simultaneously in a dynamic context. Making such a model usable involves tracing through the structure of the model in order to find out why certain variables might diverge from their historical time paths. This phase of modeling as well as such tasks as evaluating the sensitivity of a model to such factors as changes in estimated coefficients or in the paths of exogenous variables lends itself well to the microcomputer. The same is true of calculating simulation error statistics, dynamic multipliers, or dynamic elasticities.

In the past, trade forecasting at USDA has been the domain of country and commodity experts, with only limited, if any, input provided by world trade models. This has been due, in large part, to the weak empirical content of many existing agricultural trade models. It is also true, however, that these models get only limited use in forecasting exercises and situation and outlook work because of the time, expense, and expertise needed to build, operate, and maintain these models on the mainframe. The ability to facilitate the combining of expert opinion with model forecasts to produce composite forecasts was one of the main reasons for moving the GOL modeling effort to the microcomputer. It is believed that this will lead to an improvement in forecasting over either approach done in isolation.

Creating and operating a simple version of the GOL model on the microcomputer has proven to be a valuable exercise in terms of what has been learned about the potential of modeling on the micro. The payoff has thus far been primarily in expanding investment in human capital than in actual hard output. The long term payoff, however, will hopefully be in improved forecasts of agricultural trade and other variables.

References

Liu, Karen and Vernon O. Roningen, "The World Grain-Oilseeds-Livestock (GOL) Model, A Simplified Version," ERS Staff Report No. AGES850128, Econ. Res. Serv., U.S. Dept. Agr., 1985.

Roningen, Vernon O., John Wainio, and Karen Liu, "The World Grain-Oilseeds-Livestock (GOL) Model, A Microcomputer Version," ERS Staff Report No. AGES850826, Econ. Res. Serv., U.S. Dept. Agr., 1985.

SORCIM/IUS Micro Software, SuperCalc3 (Release 2) - User's Guide and Reference Manual, Second ed., rev. 1984, San Jose, CA.