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A DESCRIPTION OF "AGMOD" — AN ECONOMETRIC MODEL OF U.S. AND WORLD AGRICULTURE

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The Department of Agricultural Economics at Michigan State University has been involved with the development and application of large-scale econometric models in agriculture since the early 1970s when Deere and Company provided funding for a project. The product of this effort was the development of the "MSU Agriculture Model" which featured an extensive international component. This model was operational for a period of nearly 10 years and a number of reports were published for clientele. Useful as it was, difficulties were often encountered in de-bugging and obtaining solutions. Partly for this reason and partly due to innovations in microcomputer hardware and software, AGMOD was developed in late 1986 and early 1987.

In view of the difficulty in getting solutions to the MSU Agriculture Model but greatly in need of long-term projections, new approaches to model development were explored. The plan was to build a fairly simple model that could be easily updated and managed and then refined and enlarged as time and resources would permit. Simplicity, consistency and solvability were high on the criteria list.

Fortunately, new software was introduced in 1986 that facilitated model development. Micro TSP has been available for a number of years with new versions marketed regularly by David M. Lilien of Quantitative Micro Software. These programs have been particularly useful in least squares analysis with time series data. The capacity of the program increased and model building capabilities were added. With the introduction of Version 5.0 in 1986, the number of variables this program could handle increased from 150 to 300 (Hall and Lilien). This version requires 384K of RAM, but will use up to 512K if available. Up to 10,000 data points are allowed for 384K and up to 32,000 data points for 512K. Version 5.1 is now available which is similar to 5.0, but with more facility for interaction with Lotus 1-2-3.

A feature of these recent editions of Micro TSP is the ease with which models can be developed and solved. Micro TSP can solve linear or nonlinear systems of equations by the Gauss-Seidel method.

Least squares equations can be estimated and stored and then later retrieved with the EDIT facility. Equations can also be typed in directly in the EDIT mode. A number of operators and functional forms are available to generate the desired relationships.

Graphics can be developed quickly and used as a diagnostic tool as well as for generating visuals. The GRAPH command creates a two variable dot graph [or with GRAPH(C) a dot graph with successive years connected]. The PLOT command generates a chart of one or more variables over time with several options for scaling.

Developing AGMOD

The first step was to estimate the behavioral equations using linear regression. The model was constructed with these and a number of transformation or linkage equations. The basic model was completed in about three months. Since completion of the basic model, efforts have been devoted to refinements and testing. While the conceptual framework was fairly well in mind at the outset, all of the behavioral equations were estimated from scratch even though some earlier estimates were available from previous studies. The point is that fairly comprehensive models can be developed by this process in a relatively short time with limited resources.

AGMOD has currently 218 equations, of which 55 are behavioral and 163 are transformations. The model includes 181 endogenous, 37 exogenous variables, and a number of "dummy variables." About 290 of the maximum 300 variables have been used in the core model. Most of the statistical relationships were based on annual data for

1960 to 1987 or 1988. The commodity coverage includes cattle, hogs, broilers, turkeys, eggs, milk, corn, other feed grain, wheat, soybeans, soybean meal, and soybean oil. The entire model--data base, work file and edit file--is on one floppy disk.

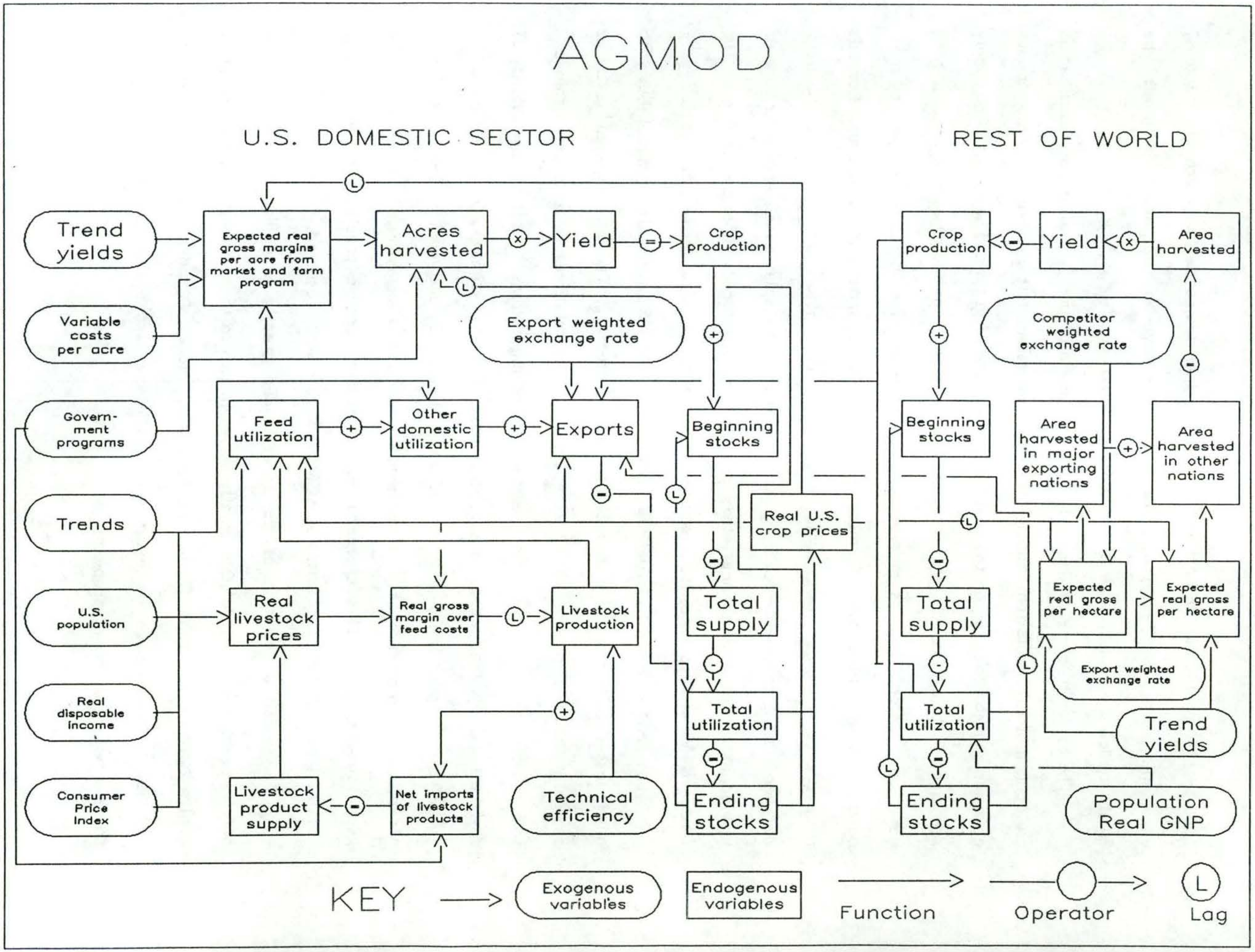
The basic structure of the model is presented in Figure 1. It would be described as an econometric simulation model--primarily recursive, but involving a simultaneous equation solution focusing on the real U.S. farm price of grain and soybeans. The supply equations feature gross margins over variable costs on crops and gross margins over feed costs on livestock. Gross margin type variables provide indicators of profits from enterprises over time. Many farmers are familiar with partial budget analysis. For this reason, expected gross margins may well represent a major consideration in farmers' decision making process. Because gross margins tend to display consistency over time or change in a consistent manner, they provide a means for diagnostic checking of the forecast. Major departures from past levels or trends are cause for re-evaluation.

The general format of AGMOD is similar to the MSU Agriculture Model, but with much less detail, especially in the international sector. The international sector is basically the "rest of the world" except that supply relationships on coarse grain and wheat are separately derived for the major exporting nations. Also, the availability of soybeans and soybean meal from Argentina and Brazil was estimated from a sub model.

With an upper limit of 300 variables in Micro TSP, one must be very selective in order to develop a reasonably comprehensive model. Consequently, the model had to be kept fairly simple. This approach was effective because problems encountered in obtaining solutions in early forms of AGMOD were quickly resolved.

The speed of solution of the model aided greatly in model development and diagnostic checking. AGMOD normally solves in two to three minutes on an IBM-AT or Zenith 248-82. This rapid feedback enhances the modeler's understanding of the system and ability to improve its estimation. The graphics options were also employed frequently for identifying problems.

Figure 1


AGMOD
U.S. DOMESTIC SECTOR
REST OF WORLD
Trend yields
Expected real gross margins per acre from market and farm program
Acres harvested
Yield
Crop production
Variable costs per acre
Export weighted exchange rate
Govern-ment programs
Feed utilization
Other domestic utilization
Exports
Beginning stocks
Trends
Real U.S. crop prices
U.S. population
Real livestock prices
Real gross margin over feed costs
Livestock production
Total supply
Real disposable income
Total utilization
Consumer Price Index
Livestock product supply
Net imports of livestock products
Technical efficiency
Ending stocks
Crop production
Yield
Area harvested
Competitor weighted exchange rate
Beginning stocks
Area harvested in major exporting nations
Area harvested in other nations
Total supply
Expected real gross per hectare
Expected real gross per hectare
Export weighted exchange rate
Total utilization
Trend yields
Ending stocks
Population Real GNP
KEY
Exogenous variables
Endogenous variables
Function
Operator
Lag
L

For each statistical equation which was entered into the model, several alternative equations were estimated--in some cases as many as five to ten alternative formulations. The equation with the strongest logical and statistical properties was then selected for inclusion. Another test was to observe the estimate of the endogenous variables in the model solution for the historical period and the forecast for the projection period. The estimated values were compared to the actual over the historical period as one test. The other test was to check how "reasonable" were the forecasts into the future.

As the model grew in size, a decision was made to forego the ability to compare the estimates from the model with the actual. To evaluate the tracking performance of the model, two codes were required for each variable--actual and estimated. This would substantially limit the number of variables that could be included. Therefore, in order to enlarge the model, each variable was given only one code name which represented actual values over the historical period and forecast values in the future. This step, of course, precluded evaluating the tracking performance of the model. Hopefully, new software will become available that will increase the upper limit on variables.

The size of the model is an asset in terms of updating. The U.S. Department of Agriculture, which is the source of most of the data, revises their estimates for the current year frequently, often monthly. Even recent years' numbers are subject to fairly regular change. Updating requires one to two hours of time each month.

For the first year into the forecast period, decisions have to be made as to whether to use the model forecasts or new government or trade estimates. As the year proceeds, the government or trade estimates begin to be given more weight than the model forecasts. By the application of "add" factors in the EDIT mode, the model forecasts can be adjusted to match the emerging actual figure.

To transcend the variable number limitation of Micro TSP, "supporting" and "satellite" models have been developed. For example, a model was constructed with each of the major grain exporting nations included in order to generate a collective area response function. Rather than having to incorporate separate harvested areas, exchange rates, consumer price indices, yields, etc., for each nation, the variables were condensed to one set. Some information is lost in this aggregation procedure, but this step is necessary to conserve on use of variables in the core model. A similar "supporting" model was developed for Brazil and Argentina on soybeans.

Satellite models refer to those which draw upon the output of the core model, but do not, in any significant way, affect the core model. Such models include supply and demand analysis on dry beans, potatoes, and vegetables, a procedure for predicting retail food prices, and a model on Michigan farm prices and incomes. For the 1988 AAEA pre-conference symposium on "Large-Scale Models and Economic Policy Analysis," a satellite model was developed which generated those variables needed for the symposium, but which were not included in the core model--such as U.S. cash receipts from crops and livestock, net cash farm income, value of exports, acreage equivalent of stocks, etc.

The procedure for solving the satellite models is fairly simple. Projections for selected endogenous variables from the core model are stored and then retrieved as exogenous variables in the satellite models.

Use for AGMOD

To date, the main use for AGMOD has been in generating long-range projections. The model is geared to forecast annual averages for each year to the year 2000. This information has been used as background information for outlook presentations and providing a perspective on past trends as well as scenarios of the future. "What if" questions can be easily addressed and quick feedback is provided from alternative assumptions. "Live" demonstrations in extension programs have been tried and show promise as an educational tool.

Another application has been to provide input into budgets for representative farms. This facilitates the development of long-term financial plans including cash flow, balance sheets, and capital budgets. "Chapter 11" proceedings have drawn upon AGMOD for the purpose of generating long-term financial plans for the farms involved.

AGMOD can be used for policy analysis. The current version employs program parameters of the Food Security Act of 1985 and accounts for the implementation of the Conservation Reserve. The price support on milk and the counter-cyclic beef import program are incorporated as well. Most of the major issues in agricultural policy national in scope can be explored by AGMOD directly or with minor modifications. Also, questions related to new technology can also be addressed.

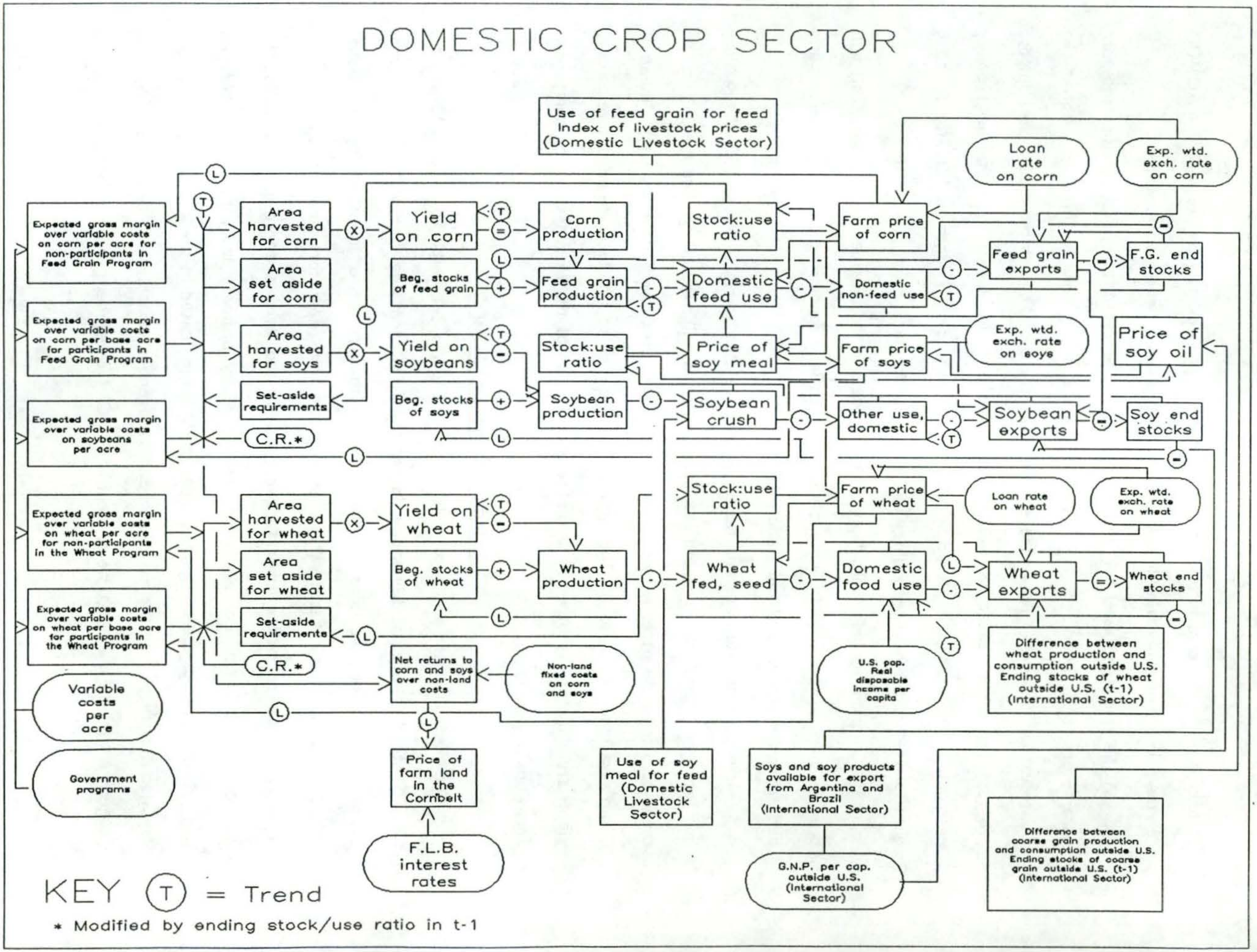
Future plans include more "supporting" models in the international sector. This will provide more insight into the impacts of differential economic growth rates abroad and differences in agricultural and trade policies.

Also contemplated are additional projects related to risk. Micro TSP has random number generators; one of which returns a uniformly distributed random number in the range of 0 to 1; the other return is a normally distributed random number with a mean of 0 and a variance equal to 1. One application would be to simulate the departure of crop yields from trends. Another is to simulate the errors of the forecasts of the component equations in the model.

Detailed Description of AGMOD

The details of the model are illustrated in Figures 2-4 which are labeled "Domestic Crop Sector," "Domestic Livestock Sector," and "International Sector." These figures include the major variables in the model with arrows to indicate the functional relationships and linkages. Where appropriate, the operators are indicated in the linkages. Except where operators are used, the arrows represent primarily the components of behavioral equations, estimated by ordinary least squares regression. Lagged relationships are designated with an "L" as indicated in the key to Figure 2. The key also illustrates how the exogenous and endogenous variables are designated. Special exogenous variables, "T" (time or trend) and "G" (government program parameters), are

Figure 2


DOMESTIC CROP SECTOR
Use of feed grain for feed Index of livestock prices (Domestic Livestock Sector)
Expected gross margin over variable costs on corn per acre for non-participants in Feed Grain Program
Expected gross margin over variable costs on corn per base acre for participants in Feed Grain Program
Expected gross margin over variable costs on soybeans per acre
Expected gross margin over variable costs on wheat per acre for non-participants in the Wheat Program
Expected gross margin over variable costs on wheat per base acre for participants in the Wheat Program
Variable costs per acre
Government programs
Area harvested for corn
Area set aside for corn
Area harvested for soys
Set-aside requirements
C.R.*
Area harvested for wheat
Area set aside for wheat
Set-aside requirements
C.R.*
Yield on corn
Beg. stocks of feed grain
Yield on soybeans
Beg. stocks of soys
Yield on wheat
Beg. stocks of wheat
Net returns to corn and soys over non-land costs
Non-land fixed costs on corn and soys
Price of farm land in the Cornbelt
F.L.B. interest rates
Corn production
Feed grain production
Stock:use ratio
Soybean production
Wheat production
Stock:use ratio
Domestic feed use
Price of soy meal
Soybean crush
Stock:use ratio
Wheat fed, seed
Use of soy meal for feed (Domestic Livestock Sector)
Farm price of corn
Domestic non-feed use
Farm price of soys
Other use, domestic
Farm price of wheat
Domestic food use
Loan rate on corn
Exp. wtd. exch. rate on corn
Feed grain exports
F.G. end stocks
Exp. wtd. exch. rate on soys
Price of soy oil
Soybean exports
Soy end stocks
Loan rate on wheat
Exp. wtd. exch. rate on wheat
Wheat exports
Wheat end stocks
Difference between wheat production and consumption outside U.S. Ending stocks of wheat outside U.S. (t-1) (International Sector)
U.S. pop. Real disposable income per capita
Soys and soy products available for export from Argentina and Brazil (International Sector)
G.N.P. per cap. outside U.S. (International Sector)
Difference between coarse grain production and consumption outside U.S. Ending stocks of coarse grain outside U.S. (t-1) (International Sector)
KEY (T) = Trend
* Modified by ending stock/use ratio in t-1

abbreviated for convenience. Definition of the model variables are listed in Appendix A and B.

Nearly all of the relationships are linear. The only nonlinear variables are logarithms of the ending stock:utilization ratios in the price equations for corn, wheat, soybean meal and soybean oil and multiplicative relationships connecting area and yields to production and prices and yields to gross returns. Although not specifically noted in Figures 2-4, all of the price, income, gross margin, gross return, and gross national product variables are in real terms. The Consumer Price Index was used to deflate the U.S. variables. Other deflators were tried, but generally added little to the explanatory performance of the equations.

The three sectors are linked by several variables including the price of corn, soybeans, soybean meal and wheat. Other linkages are indicated in the diagrams. Crop data are in terms of crop years and livestock data are in terms of calendar years.

Domestic Crop Sector

The supply side of the Domestic Crop Sector keys on the expected gross margin over variable costs per acre on corn, soybeans and wheat. Variable costs are exogenous to the model. On corn and wheat, expected gross margins are divided into participants and nonparticipants in the Feed Grain and Wheat Programs.

The expected gross margin over variable costs for nonparticipants in the Feed Grain Program is simply the lagged farm price of corn times trend yield less the variable costs per acre. As with all price and income variables, the nominal gross margin is deflated by the Consumer Price Index.

The expected gross margin over variable costs for participants in the Feed Grain Program is calculated relative to a base acre and not the acre actually harvested. On the portion of the base allowed for planting and harvesting, the expected return from the market is the expected price times trend yield less variable costs. The expected price is the higher of the previous year's farm price of corn or the loan rate for the current year. This formulation is designed to capture the provision for the participants who take the loan knowing they can either deliver to CCC (if prices are not enough above the loan to profit from selling the corn on the market and paying back CCC) or sell the corn and pay back the loan.

Since corn and soybeans are close substitutes in production, area devoted to the two crops were combined in the supply analysis. The focus was on the total area devoted to acres of corn harvested and set aside plus harvested acres of soybeans. The reason planted acres were not considered was strictly due to the limitation in terms of the number of variables which could be included in the entire model. Normally, harvested acres are closely correlated with planted acres.

As indicated in Figure 2, the expected gross margins for participants and nonparticipants in the Feed Grain Program and for soybean producers are combined (weighted by acreage) in the formulation of a supply equation. The dependent variable in the supply equation is the total acreage harvested and set aside on corn and harvested on soybeans. The major independent variable is the actual gross margin for these combined enterprises over the previous seven years. This long lag reflects the time required for adjustment to profitability on a major sector of crop agriculture in the U.S.

To determine the allocation of this area to acreage harvested for corn and set-aside and acreage harvested for soybeans, the relative profitability of corn (both for participants and nonparticipants in the Feed Grain Program) versus soybeans was incorporated in an equation which predicted the percentage to each. The result was a shorter lag of four years to determine the allocation between corn (acres harvested and set aside) and soybeans. Another equation was estimated to establish the acres harvested for corn and acres set aside in the Feed Grain Program. This equation incorporated the difference between the expected gross margin over variable costs for participants and nonparticipants in the Feed Grain Program. Also included was the set-aside requirement.

The reason this approach was followed rather than using an equation which directly tied acreage harvested to returns from participation and nonparticipation was due to the predominant role that the farm program has played in planting decisions since 1960. Efforts to estimate supply equations with this latter approach resulted in inappropriate relationships in projection periods with free market scenarios. In other words, should farm programs similar to those since 1960 not be needed, equations directly predicting corn acres harvested (and based on years in which a farm program predominated) gave results inconsistent with those expected from economic theory.

This formulation generated corn acres harvested, corn acres set aside and soybean acres harvested. A similar approach was used on wheat. One equation was estimated to predict the total area harvested for wheat and set-aside. This was a function of expected gross margins from participation and nonparticipation in the Wheat Program weighted by acreage in each alternative. As with corn, the acreage harvested was based on the difference between gross margins from participating versus not participating and the set-aside requirement.

The area set aside under the Conservation Reserve was not explicitly modeled. However, the reduction in total area available to corn, soybeans and wheat including the respective set-asides was entered exogenously in concert with area projected to enter the Conservation Reserve. The base run assumes that the targeted 45 million acres will by in CR by 1990.

As shown in Figure 2 on the Domestic Crop Sector, area harvested times trend yield equals the projected production on corn, soybeans and wheat. Total feed grain production is generated from corn production and a trend factor. Yields are assumed to be a linear function of time. While more refined procedures could be used to forecast yields by including product price-input price ratios and proportion of acres in the set-aside, the additional precision was judged to be less important than preserving variables for other uses.

The model generates the standard components of the balance sheets on crops. Feed grain used for feed is derived from variables which represent the standard rations for the different classes of livestock included in the model, but modified in the aggregate by livestock prices, corn prices and soybean meal prices. Nonfeed use is a function of trends. Feed grain exports are forecast from the projected deficit outside of the U.S., the ending stocks of coarse grain outside of the U.S. in the previous year and the real trade weighted exchange rate on corn. Use of the "rest of the world" deficit in absence of a price variable reflects the inelasticity of coarse grain use abroad. The farm price of corn was tried, but found to be an insignificant influence in the "within year" exports of feed grain. In the longer-run, corn prices do affect exports of feed grain. The variable on ending stocks outside of the U.S. in the previous crop year was incorporated to model policy decisions made by foreign governments to shore up depleted stocks. The exchange rate provides a measure of the competitive position of U.S. exports.

Ending stocks of feed grain are compared to total utilization to derive the stock:utilization ratio which, in turn, is an important determinant of the farm price of corn. Another factor which helps to establish the lower bounds on corn prices is the government loan rate. The real export weighted exchange rate on corn adds some additional explanatory effect to the price of corn equation.

The stock:utilization ratio is also used to endogenize part of the farm program. The previous year's stock:utilization ratio is the determinant of the set-aside requirement. This relationship is based on past responses by the Secretary of Agriculture to carry-over levels.

Total utilization of soybean meal is generated in a manner similar to feed grain for livestock feed. Amounts which represent what would be fed with fixed rations enter an equation which also incorporates an index of the price of livestock, the price of meal and the price of feed grain. Total utilization of soybean meal and soybean exports are the explanatory variables for domestic crush of soybeans. Since meal is exported as well as fed domestically, some indicator of exports is necessary--in this case, raw soybean exports were used.

Soybean exports are forecast from an indicator of demand--the gross domestic product outside the U.S.--coupled with the availability of soybean and soybean products to world markets from Argentina and Brazil, feed grain exports, the farm price of soybeans and the trade weighted exchange rate for soybeans. Ending stocks are divided by total soybean utilization to generate the stock:utilization ratio which, in conjunction with the farm price of corn, are the major influences on the price of soybean meal. Also affecting the price of soybean meal is the real export weighted exchange rate on soybeans.

The price of soybean oil is also affected by the stock:utilization ratio along with the gross domestic product outside of the U.S. The predicted values for soybean meal and oil are combined according to the normal extraction rates from a bushel of soybeans and this derived "product value" is used to predict the farm price of soybeans.

On wheat, the amounts fed to livestock relate to the ratio between wheat and corn prices. Domestic food use is a function of the U.S. population, disposable income and trends. Like feed grain, the major factor explaining wheat exports is the deficit outside of the U.S. Other contributing factors include the farm price of wheat in the previous year and the ending stocks of wheat outside the U.S. the year before. As with coarse grain, the rationale for the ending stock variable is to measure the response of foreign governments in replenishing depleted supplies.

Similar to feed grain and soybeans, an ending stock:utilization ratio is derived for wheat which is the major explanatory factor for the farm price of wheat. The loan rate sets the lower bounds on wheat prices and international competition is reflected by the real export weighted exchange rate. As with feed grain, the previous year's ending stock:utilization ratio is employed to establish the set-aside requirement in the Wheat Program.

The farm prices on corn, soybeans and wheat derived by the process outlined in the Domestic Crop Sector are fed back into the system in a lagged formulation. The lagged prices become a major component in the expected gross margin over variable costs for each of the crops. This generates another year of forecasts which, in turn, is the basis for predicting the following year and so on. The crop sector and the entire model are primarily recursive although some simultaneous relationships can be detected. For example, feed grain and soybean meal use affect corn and soybean meal prices, but, at the same time, these prices also affect utilization of feed.

A variable not needed for solving the crop sector, but which does enter the livestock sector, is the price of farmland in the Corn Belt. The gross margins on corn and soybeans are combined with estimates of fixed nonland costs for corn and soybeans. This variable lagged is the main element in explaining land prices along with interest rates on farm mortgages as reported by the Federal Land Bank.

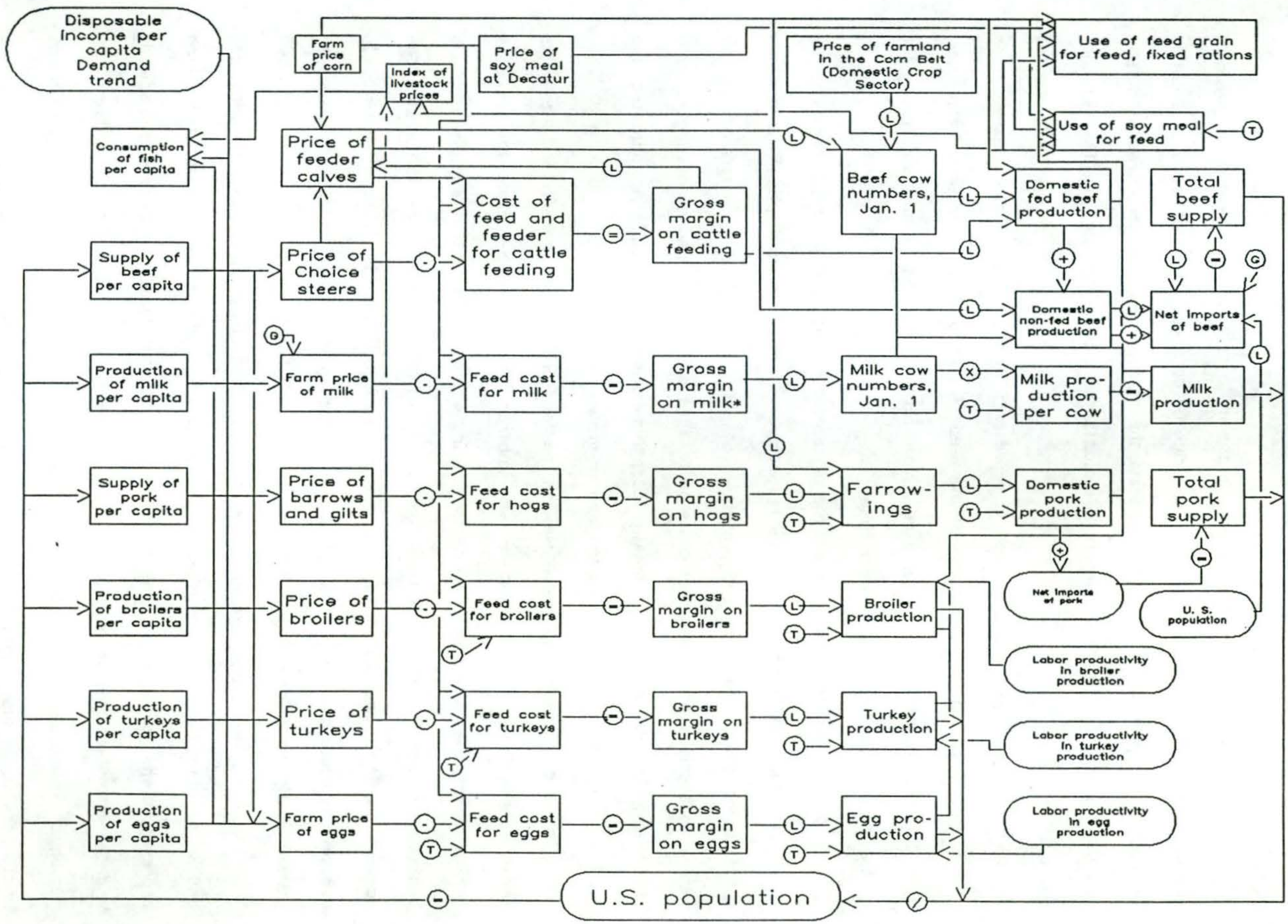
Domestic Livestock Sector

The domestic livestock sector is charted in Figure 3. The focus is to generate gross margins over feed costs for major livestock enterprises to drive the supply equations. Since exports of livestock products are minor, the resulting supplies are divided by the U.S. civilian population to derive per capita supplies. Per capita supplies of livestock products are the major determinants of market prices. Disposable income and demand trends also are important in explaining livestock prices over time.

Beef. The decisions of cow-calf operators are most important for establishing what beef supplies will be in the future. The analysis of factors influencing this decision indicated that the price of feeder calves over the most recent three years was predominant modified somewhat by the price of land. While the relevant land price would cover more than the Corn Belt, the Corn Belt farmland price was used as a proxy to conserve on the use of variables.

Figure 3

DOMESTIC LIVESTOCK SECTOR



* Converted to gross margin per cow by multiplying by milk production per cow

The current price of Choice steers is the main driving force behind the price of feeder calves. But also important is the price of corn and the profitability of cattle feeding in the previous year. This suggests that the price of feeder calves is mostly demand driven. Efforts to incorporate indications of the available supplies were not successful.

The gross margin in cattle feeding represents the return from the finished steer over the cost of both the feeder animal and feed. Again to conserve on use of variables, only the calf program was incorporated. However, it serves as a reasonable proxy for cattle feeding profits in general over time.

Another compromise was to use the price of corn and soybean meal as proxies for feed prices in cattle feeding. The respective prices were multiplied by numbers representing standard energy and protein inputs into a calf feeding program. To the extent that prices or opportunity costs on forages such as hay and corn silage bear a relationship to corn and soybean meal prices, this assumption is valid. As indicated, the feed costs represent both purchased and home-grown feeds.

The price of feeder calves as well as the feed prices were transformed into costs per hundredweight of finished steer. By subtracting this number from the price of Choice steers, the gross margin on cattle feeding was calculated. With appropriate lags, beef cow numbers along with the gross margin from cattle feeding determined the domestic fed beef production. The current price of corn was also incorporated to help explain the average marketing weights. When corn prices rise, cattle feeders tend to market at lighter weights than usual.

Domestic nonfed beef production is composed primarily of cull cows from both beef and dairy operations. To predict this quantity, a variable was constructed which represented the normal replacement of cows to maintain constant numbers in the herds and the actual change from January 1 to the next January 1 in beef and dairy cow numbers. An increase in numbers would imply a reduction in cow slaughter and a decline in numbers would imply liquidation and higher cow slaughter.

This variable was quite significant in the estimating period in accounting for nonfed beef production. However, it requires solution on the number of beef and dairy cows on farms on January 1 of the following year. This caused a problem with the Gauss-Seidel solving procedure for the prediction period. For that reason, an alternative equation was derived from lagged feeder calf prices, the level of cow numbers on farms on January 1 of the current year and normal replacement rates.

Imports of beef are primarily from Australia and New Zealand and directly competitive with domestic nonfed beef. These imports are restricted by the counter-cyclic Meat Import Law. The application of this law is endogenous in the model by application of the domestic production of nonfed beef, lagged values of total domestic beef production and lagged U.S. civilian population. Beef imports and exports are not explicitly predicted, but are combined in the dependent variable, net imports of beef. Net imports of beef added to domestic fed beef production and domestic nonfed beef production equal the total supply of beef in the U.S.

Dairy. The gross margin on milk is calculated by subtracting the cost of a standard ration for dairy cows from the farm price of milk. As with cattle feeding, the prices of corn and soybean meal serve as proxies for the cost of energy and protein in dairy rations. To account for the impact on profits from the increasing productivity, the gross margin per hundredweight of milk was multiplied by the milk production per cow. This variable lagged over the previous three years provided the explanation for the number of dairy cows on farms on January 1.

Milk production per cow was generated as a linear function of time. The product of dairy cows on farms on January 1 and milk production per cow equals total milk production. Dividing total milk production by the U.S. civilian population gives the milk production per capita which affects the price of milk.

However, the most important variable influencing milk prices is the support price on manufacturing milk. In many years, the government has had to purchase dairy products in order to maintain manufacturing milk prices at the support level. The support price is predicted exogenously except that after 1990, the support is assumed to be related to the feed cost for milk. Other variables affecting the price of milk are disposable income per capita which has a modest positive effect on milk prices and trends which have a negative effect.

Hogs. The gross margin over feed costs on hogs is calculated from the market price on barrows and gilts less standard ration costs in a farrow-to-finish operation. As with beef and dairy cattle, the costs apply both to feed purchased and feed raised on swine farms. The rationale is that hog farmers have the option of selling corn rather than feeding it.

This alternative was particularly noticeable during the mid 1970's when corn prices were quite high. For this reason, not only gross margins over feed costs were found significant in determining subsequent farrowings, but also recent corn prices seemed to have a separate significant impact. Over time, the supply function on farrowings has shifted to the left as measured by a trend variable.

The dependent variable in the supply function on hogs was spring farrowings since the expansion or contraction decision appeared to focus on that season. Fall farrowings were derived from spring farrowings with two trend factors, one to capture the rapid shift to multiple farrowings through the mid 1970's and the other to measure a much less pronounced trend since that time.

Farrowings in the previous fall and in the current spring were the basis for estimating pork production. A significant increase in productivity of the swine herd since the mid 1970's was taken into account with a trend variable. Net imports of pork were added exogenously to domestic pork production to derive the total pork supply.

Poultry. The derivation of the supply and demand relationships on broilers, turkeys and eggs proceeded in an identical manner. The gross margins over feed costs were not calculated from fixed rations, but trends to improved feed conversions were incorporated in the feed cost estimates.

To conserve on use of variables, the impact of gross margins over feed costs on subsequent poultry production was measured directly. That is, rather than introducing egg placements, poultry numbers, eggs per layer, etc., total production was the dependent variable. The effects of technological and structural changes were handled by trend variables and an estimate of labor productivity in each of the poultry enterprises.

Red Meat and Poultry Prices. Because of the close interlinkages in demand between the various red meat and poultry enterprises, the price equations will be described in concert. Considering that supplies or production per capita for red meat and poultry meat in any given year are largely predetermined by decisions in the previous year or years, prices were entered as dependent variables in the demand equations. Rather than prices of substitutes affecting the demand for a particular commodity, the supply or production per capita was incorporated to measure the substitute effect. This procedure reduces the problem of multicollinearity which is often encountered in single equation demand analysis when own and substitute prices are independent variables with consumption as the dependent variable.

Because time series analysis has certain limitations in terms of measuring the separate own and cross effects from per capita supplies, effects of consumer income, changing tastes, etc., some simplifying assumptions were made in formulating the demand equations. The red meat and poultry meat supplies per capita were converted to an "edible weight" basis. This allows for more accurate additivity among the meats and also facilitates adding fish consumption which traditionally has been reported in edible weights. Fish (including shellfish) is becoming a more important feature in American diets and will likely become more prominent in the future.

The demand equations for the meats were quite similar. The independent variables included the supply (or production) per capita (in edible weight) of the given product, the aggregate supply per capita of the other three meats plus fish consumption, disposable income per capita and trend. While the per capita production of eggs did not enter the meat equations, the per capita supply of meat (red and poultry) was an independent variable in the egg price equation. Other independent variables in the egg price equation included the per capita supply of eggs, disposable income (positive effect) and trends (negative effect).

The signs on the own and cross supply effects on all the livestock products were negative as expected. The effects were statistically significant at the 95 percent level except on beef substitutes. The impact of disposable income per capita was positive and statistically significant on all the meats.

Perhaps the most challenging factor in the demand for livestock products is the trend effect. Concerns about health and diet and guests for convenience in food preparation have generally been recognized to have become much more evident in American lifestyles in the past decade. Published research and popular notions have been mostly negative with regard to red meat consumption. Inspection of single equation demand equations both at the wholesale and retail levels on beef and pork indicated a marked shift in demand trends around 1976.

The profession of agricultural economists is divided on whether or not we have had a structural shift in demand for livestock products since the mid 1970's. Those oriented to demand systems analysis question whether there has been a perceptible change in structure while those using single equations generally believe that a significant shift in demand has occurred. In any case, those economists with the responsibility for predicting livestock prices frequently erred on the high side on cattle and hog prices during the first part of the 1980's. While the demand component of AGMOD does not incorporate the systems approach, the evidence from the single equation approach over the 1960 to 1987 period strongly suggests that demands have shifted at different paces since the mid 1970's.

Two trend variables were included in each demand equation in the domestic livestock sector. One measured demand shifts up through 1976 and the other measured demand shifts after 1976. On all of the livestock products, the demand shifts were negative throughout the 1960 to 1987 period. However, significant differences were observed in the rate of the shift after 1976. On beef, pork, eggs and milk, the negative trend was greater after 1976, significantly so on beef and pork. On broilers and turkeys, the downward shift in demand continued, but leveled off after 1976, significantly so on turkeys.

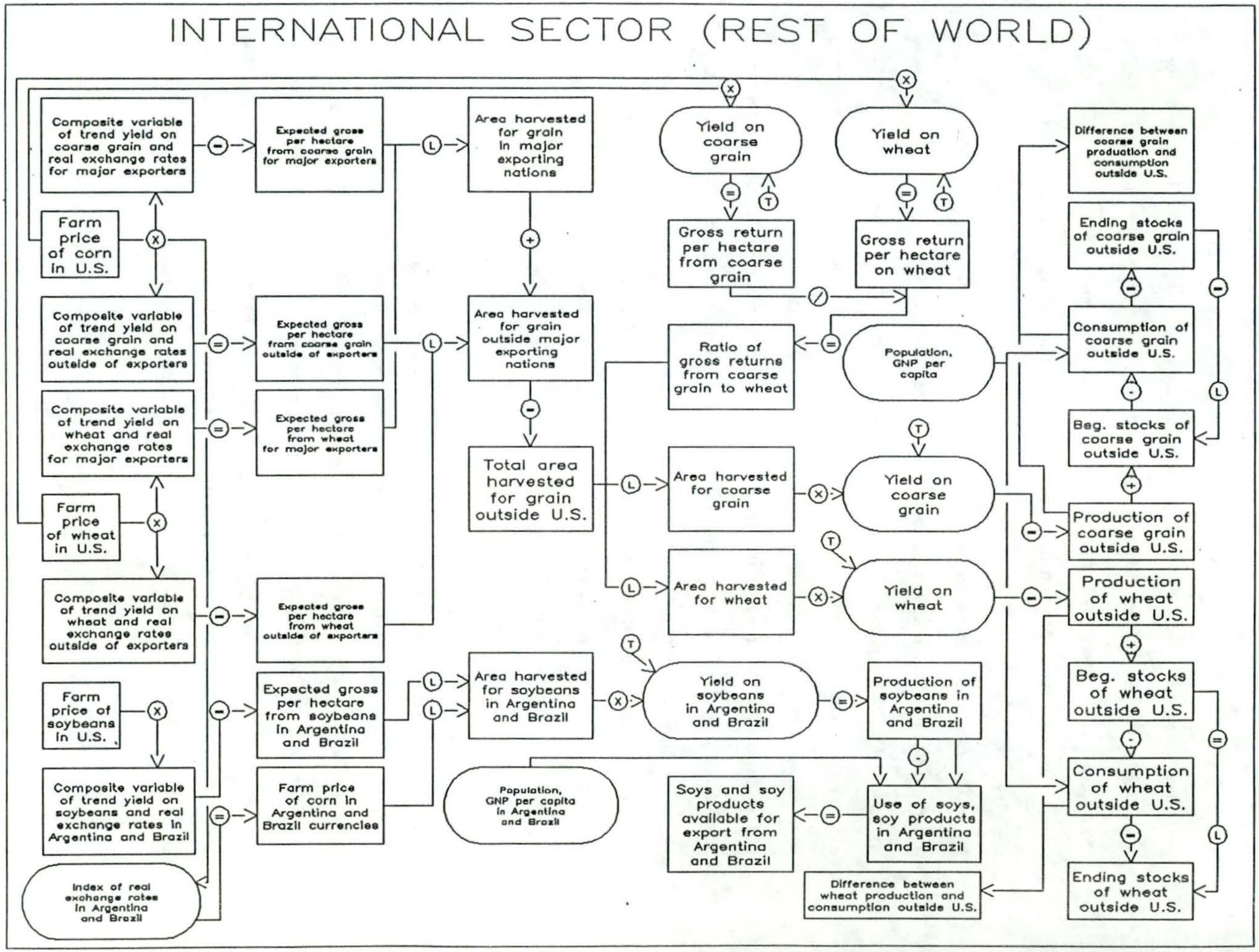
The challenge is to interpret these shifts for the future. Will the downward shifts continue linearly in the 1990's as took place in the late 1970's and 1980's? For the base run of AGMOD, the assumption was made that the rapid shift in consumption to more poultry meat would abate in the 1990's. The shift would continue, but not at the pace of the past decade. The downward shift in demand for beef, pork, eggs and milk would level off some in the 1990's, but would not end. These assumptions are, of course, tentative and will be modified if developments in the near future indicate alternative scenarios.

The projection on fish consumption is derived from consumer income projections, the index of livestock prices and trends. The trend effect was slightly negative up to 1976 and slightly positive afterward. The most significant factor was the positive effect of income. Due to lack of data and model limitations, the price of fish was not incorporated.

International Sector

A schematic of the international sector is displayed in Figure 4. This sector in the model is fairly aggregative and geared to the most salient information needed to generate U.S. exports of feed grain, soybeans and wheat. A supporting model outside of AGMOD was developed for grain areas in the major exporting nations of Canada, Australia and Argentina. Similarly, a supporting model was estimated on soybean area, production and exportable supplies in Argentina and Brazil. Parts of these models were incorporated directly in AGMOD and other parts were included as combined terms.

Figure 4


INTERNATIONAL SECTOR (REST OF WORLD)
Composite variable of trend yield on coarse grain and real exchange rates for major exporters
Expected gross per hectare from coarse grain for major exporters
Area harvested for grain in major exporting nations
Yield on coarse grain
Yield on wheat
Difference between coarse grain production and consumption outside U.S.
Farm price of corn in U.S.
Gross return per hectare from coarse grain
Gross return per hectare on wheat
Ending stocks of coarse grain outside U.S.
Composite variable of trend yield on coarse grain and real exchange rates outside of exporters
Expected gross per hectare from coarse grain outside of exporters
Area harvested for grain outside major exporting nations
Ratio of gross returns from coarse grain to wheat
Population, GNP per capita
Consumption of coarse grain outside U.S.
Composite variable of trend yield on wheat and real exchange rates for major exporters
Expected gross per hectare from wheat for major exporters
Beg. stocks of coarse grain outside U.S.
Total area harvested for grain outside U.S.
Area harvested for coarse grain
Yield on coarse grain
Production of coarse grain outside U.S.
Farm price of wheat in U.S.
Composite variable of trend yield on wheat and real exchange rates outside of exporters
Expected gross per hectare from wheat outside of exporters
Area harvested for wheat
Yield on wheat
Production of wheat outside U.S.
Farm price of soybeans in U.S.
Expected gross per hectare from soybeans in Argentina and Brazil
Area harvested for soybeans in Argentina and Brazil
Yield on soybeans in Argentina and Brazil
Production of soybeans in Argentina and Brazil
Beg. stocks of wheat outside U.S.
Composite variable of trend yield on soybeans and real exchange rates in Argentina and Brazil
Farm price of corn in Argentina and Brazil currencies
Population, GNP per capita in Argentina and Brazil
Soys and soy products available for export from Argentina and Brazil
Use of soys, soy products in Argentina and Brazil
Consumption of wheat outside U.S.
Index of real exchange rates in Argentina and Brazil
Difference between wheat production and consumption outside U.S.
Ending stocks of wheat outside U.S.

One of the criteria in developing the international sector was to use variables which were easy to update from regular published reports from the U.S. Department of Agriculture. Another source convenient to keep the model current is the International Financial Statistics of the World Bank.

Much difficulty is encountered in attempting to establish a world price on major crops. Lacking the capacity to explore many alternatives, the assumption was made that the U.S. farm price of corn, wheat and soybeans would serve as anchors in the quest for representative world prices. To translate these prices to other nations, indices of real exchange rates were calculated and multiplied by the respective U.S. farm prices. While the actual prices faced by producers and consumers are isolated from world prices in many nations, policy decisions in such nations are often conditioned by world prices over time. This, plus the fact that major exporting nations such as Canada and Australia are responsive to international markets, was the rationale for a focus on U.S. farm prices.

Grain. Cost of production data were not available so the key variable in the supply equations on crops was the gross return per hectare. This was calculated by multiplying the U.S. farm price of corn and wheat by a combined term representing trend yield times an index of real exchange rates. Through a weighting procedure, a variable representing the expected gross return per hectare from both coarse grain and wheat was calculated. This variable was the driving force in predicting the total area harvested for grain. Two such equations were estimated, one for the major exporting nations outside of the U.S. and the other for nations outside the U.S. and the major exporting nations.

The areas harvested for grain in the major exporting nations and the other nations are summed to produce the total area devoted to coarse grains and wheat outside of the U.S. The allocation of this total area to coarse grains versus wheat is established by the ratio of the gross returns per hectare for coarse grains to that for wheat. This involves a rather long lag covering the previous six years. Yields of coarse grains and wheat outside of the U.S. are a linear function of time. The product of area and yields establishes the production of coarse grains and wheat outside of the U.S.

Domestic utilization of coarse grains and wheat outside of the U.S. is primarily a function of population and incomes outside of the U.S. The difference between production and utilization of coarse grains and wheat outside the U.S. becomes the major determining factor in U.S. exports to these products.

Soybeans. The soybean sector in many ways parallels the grain sector. The farm price of soybeans in the U.S. is translated into the gross return per hectare in Argentina and Brazil in a free market mode. An additional influence in South America is the alternative for coarse grain represented by the localized world price of corn. These two variables account for the changes in the area harvested for soybeans in Argentina and Brazil. Area harvested times the trend yield generates the production of soybeans in these countries. Subtracting the utilization of soybean meal in soybean equivalents provides an estimate of the amount of soybeans and products available for export. This variable is a major influence on exports of soybeans from the U.S. The domestic demand for soybeans and soybean products in Argentina and Brazil is a function of population and real gross national product per capita and the availability of these products.

Because of the very rapid growth of soybean production in these these nations in the past 20 years, time series analysis may tend to project a more rapid rate of growth in the future than is realistic. For that reason, estimation was made of the total area available for grain and soybeans in these countries from now to the year 2000. By assuming that soybeans would occupy a maximum of 50 percent of this land in Brazil and 40 percent in Argentina, an upper limit was imposed on the area devoted to soybeans in both nations. Even so, the projections indicate that South America will continue to increase its share of world exports of soybeans in the next decade.

Model Elasticities and Flexibilities

The derivation of traditional demand and supply elasticities from a model such as AGMOD is somewhat complicated by the dynamic structure involved. Also the complexity of the model precludes easy estimation directly from the structural equations. Prices can be arbitrarily changed and the impact observed in the model over time. However, because prices are endogenous and because simultaneous relationships exist, the price-quantity relationships in unrestricted runs of the model are difficult to measure. Also, all of the supply equations incorporated real gross margins rather than prices. The price impact is estimated in combination with costs.

One sector which did allow direct estimation was livestock demand which involved no lags. However, since prices were dependent, and the quantities of the product and its substitutes were independent, direct estimates of the own and cross price elasticities were not possible.[1/] Instead, price flexibilities were estimated as shown in Table 1.

The "own" price flexibilities of demand were greater than $|-1|$ on all the livestock items except milk indicating inelasticity. The different result for milk can be explained by the government's role in supporting milk prices and removing products from the market when supplies are in surplus.

The availability of substitutes also has had a greater than proportional negative effect on livestock prices with the exception of beef. While beef prices are significantly affected by beef supplies, recent trends (negative) and disposable income (positive), the availability of substitutes has apparently had a minor impact. Changing disposable incomes have had a greater than proportional positive effect on livestock prices except on milk.

To measure supply elasticities on crops, real prices were set at 1988 values for the period from 1988 to 2000 for a base run. Then, prices were arbitrarily raised 10 percent for a second run and lowered 10 percent for a third run. The structure of AGMOD including some nonlinear relationships, renders elasticities dependent upon (1) the extent of the change in prices; (2) the direction of change; and (3) the length of time being considered; and (4) the years to which the elasticities apply (in this case, 1988-2000).

[1/] The inverse of the price flexibility of demand relative to quantity would approximate the elasticity, setting the lower limit.

Table 1

Price of Flexibilities of Demand On Livestock Calculated from AGMOD[a]

Effect of a One Percent Change in the Independent Variable on the Dependent Variable

Independent Variable	Dependent Variable: Price of Choice Steers	Price of Barrows & Gilts	Price of Broilers	Price of Turkeys	Farm Price of Milk	Farm Price of Eggs
Supply of beef per capita	-2.70					
Supply of pork per capita		-3.40				
Production of broilers per capita			-2.75			
Production of turkeys per capita				-1.70		
Production of milk per capita					-.83	
Production of eggs per capita						-3.09
Supply of substitutes per capita[b]	-.15	-3.14	-3.43	-5.32	--	-2.23
Disposable income per capita	3.31	3.78	4.11	4.12	.55	1.11

[a] Based on forecast values for 1988.

[b] Other meat plus fish for meat items; all meat on eggs.

Tables 2 and 3 present the results for the selected years 1988, 1989, 1993 (5 years lag), 1998 (10 years lag) and the year 2000. Only on the production of feed grain, soybeans and wheat were differences notable based on direction of price change. This is because of asymmetry in the application of farm programs in rising versus falling prices.

As noted on livestock production in Table 2, supply elasticity generally increased over time with tendency to converge to an upper limit. On beef, the very short-run elasticity (1989) was slightly negative, reflecting withholding of cows from the market for herd expansion. The inelasticity of supply on broilers and turkeys was somewhat surprising in that lagged gross margins were statistically significant in explaining their output. Because the model was specified with a minimum lag of one year, no supply response on livestock and poultry was recorded for 1988. A quarterly model would likely reveal some response within 1988, particularly on poultry.

The short-run supply elasticities (1989) on feed grain (.13-.15) and wheat (.23) were reasonable, but subsequent values and changes in signs may appear inconsistent. However, AGMOD triggers increased set asides if stocks increase. Also, if stocks reach pipeline levels, AGMOD pulls land into production through program incentives such as releasing land from the Conservation Reserve.

Demand elasticities on crops are presented in Table 3 and are separated into major uses as well as for total utilization. The pattern is generally as expected with the absolute values of the elasticities increasing over time and tending to converge. One exception is soybean exports with a relatively high elasticity of -.44 in the current year, converging to -.33 by the year 2000. This is due to an upper limit placed on the rate of expansion in areas devoted to soybeans in South America which reduces the demand elasticity of U.S. exports. The drop in the elasticity of export demand on wheat after 1998 relates to government action to either reduce stocks or rebuild them.

Since U.S. grain and soybean prices represent world prices, the export elasticities do not represent what would happen if U.S. prices were changed and prices in major exporting nations were held constant. Changing U.S. export prices implies a parallel

Table 2

Supply Elasticities on Livestock and Crops Calculated from AGMOD

Effect of a One Percent Increase in Price on the Dependent Variable [a/]

Dependent Variable	Price	Year 1988 %	1989 %	1993 %	1998 %	2000 %
Supply of beef	Choice Steers	NC	-.05	+.55	+1.45	+1.76
Supply of pork	Barrows & Gilts	NC	+.13	+.76	+1.12	+1.19
Production of broilers	Broilers	NC	+0.07	+.11	+.10	+.10
Production of turkeys	Turkeys	NC	+0.08	+.09	+.08	+.07
Production of milk	Milk	NC	NC	+.39	+1.12	+1.15
Production of eggs	Eggs	NC	+.07	+.24	+.32	+.33
Production of feed grain	Corn					
Increase in price		NC	+.15	-.14	-.80	-.72
Decrease in price		NC	-.13	+.11	+.51	+.51
Production of soybeans	Soybeans					
Increase in price		NC	+.25	+1.10	+1.22	+1.14
Decrease in price		NC	-.25	-.47	-.71	-.46
Production of wheat	Wheat					
Increase in price		NC	+.23	-.61	-.25	+.07
Decrease in price		NC	-.23	+1.10	+.84	+1.08

[a/] Both increase and decrease in price applied to crop production.

Table 3

Demand Elasticities on Crops Calculated from AGMOD

Effect of a One Percent Increase in Price on the Dependent Variable

Dependent Variable	Price	1988 %	1989 %	1993 %	1998 %	2000 %
		Year				
Feed Grain	Corn					
Fed to livestock		-.16	-.20	-.40	-.59	-.65
Exports		NC	-.07	-.61	-1.03	-1.11
Total utilization		-.10	-.13	-.40	-.61	-.66
Soybeans	Soybeans, Meal & Oil					
Fed to livestock (meal)		-.05	-.05	-.10	-.13	-.13
Crush		-.12	-.11	-.15	-.17	-.17
Exports		-.44	-.39	-.31	-.31	-.33
Total utilization		-.22	-.21	-.20	-.21	-.22
Wheat	Wheat					
Domestic consumption		NC	NC	NC	NC	NC
Fed to livestock		-.85	-1.55	-4.10	-5.86	-6.18
Exports		NC	-.12	-1.08	-2.47	-2.02
Total utilization		-.09	-.21	-.96	-1.76	-1.54

change elsewhere. The model does indicate that U.S. export demand vis-a-vis world corn and wheat prices is inelastic in the short-run, but elastic in the long-run.

Trends and Projections from AGMOD

To illustrate the type of projections derived from AGMOD, a series of charts are attached which represent some of the more salient developments in U.S. and world agriculture. The numbers reflect USDA estimates of 1988 crop conditions as of October 1, 1988. The following assumptions underlie the projections.

1. Real consumer incomes per capita will increase by 1 percent per year in the U.S. and abroad.
2. Inflation in the Consumer Price Index will average 3-4 percent per year.
3. Real interest rates will average about 6 percent as represented by farm mortgages in the Farm Credit Service.
4. Crop yields will increase in line with past trends.
5. Biotechnology will not noticeably enhance trends to increased productivity already assumed in the projections on crops and livestock.
6. The Food Security Act of 1985 will be continued into the 1990's. Loan rates and target prices will be held at 1990 levels after 1990.
7. The Conservation Reserve will reach 45 million acres by the early 1990's, but will not be expanded to 65 million acres.

The assumption concerning economic growth, particularly in the less developed nations, is probably the most crucial in charting the likely course of U.S. agriculture in the 1990's. The impact of the world recession in the 1980's is reflected in the decline in per capita consumption of coarse grain outside of the U.S. as shown in Figure 5. Since two-thirds of the coarse grain consumed abroad is through livestock, the decline represents an attenuation in the upward trend to consuming more animal protein. The projection is for a modest increase in the coming decade to a level near the peak of the 1970's.

Per capita wheat consumption continued to increase in the 1980's in foreign nations, a trend projected to continue to the year 2000. To some extent, wheat has replaced coarse grain consumed directly by the human population.

Because of the large population in the developing world and rate at which it is expanding, an increase in per capita consumption can have major implications to total demand. This is indicated in Figure 6 which displays trends and projections in total utilization of coarse grain abroad. The possible acceleration in the total utilization could put some pressure on production in these nations to keep pace. If this develops, the U.S. feed grain exports would expand to fill this gap.

A similar situation is indicated for wheat (Figure 7). As with coarse grain, the question is not whether the rest of the world is capable of expanding grain production in line with consumption. Based on past relationships, it is questionable whether the rest of the world will be able to gear up to the challenge. In Argentina and Brazil, for instance, the land which could be brought into production exceeds the projected levels of use.

The implementation of the FSA of 1985 and the drought of 1988 has changed the complexion of the carryover situation on grain rather dramatically. As shown in Figure 8, more than half of the world's carryover of coarse grains has been in the U.S. in recent years. However, by the end of the 1988-89 crop year, the sharp drop in the U.S. carryover will bring this level down to about half of the rest of the world. With expanding export demand in combination with expansion in the Conservation Reserve, stock levels are projected to remain below that of recent years, but a little above the 1970's.

Figure 5

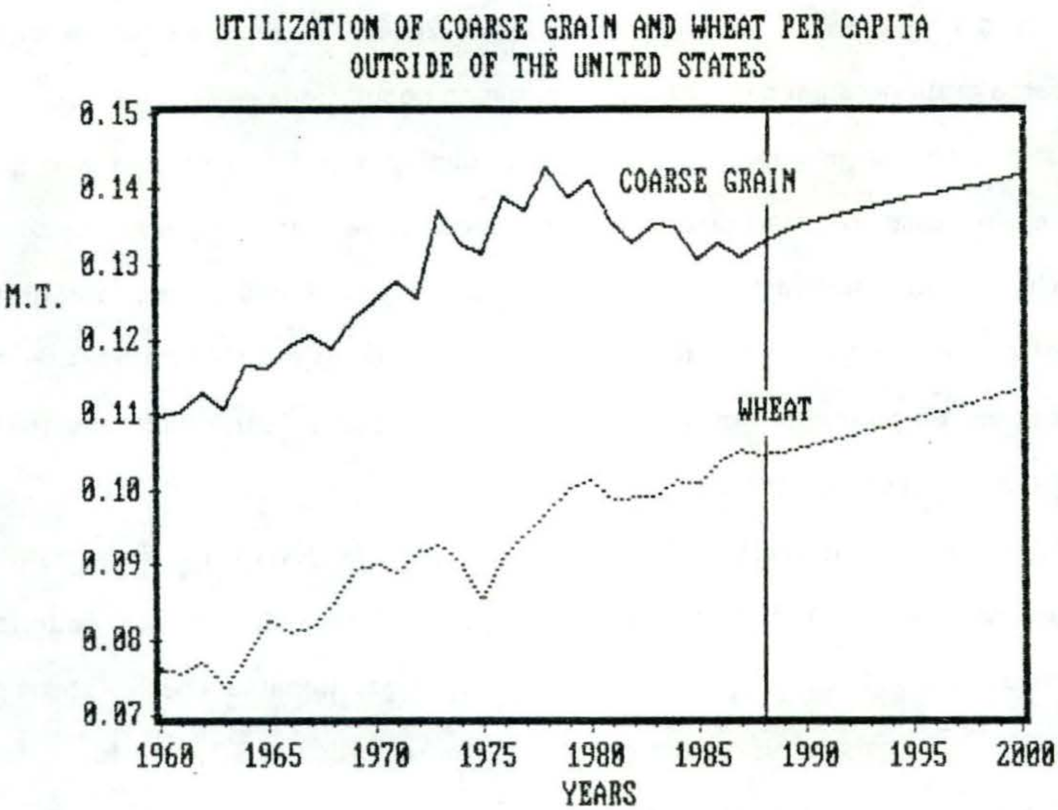


Figure 6

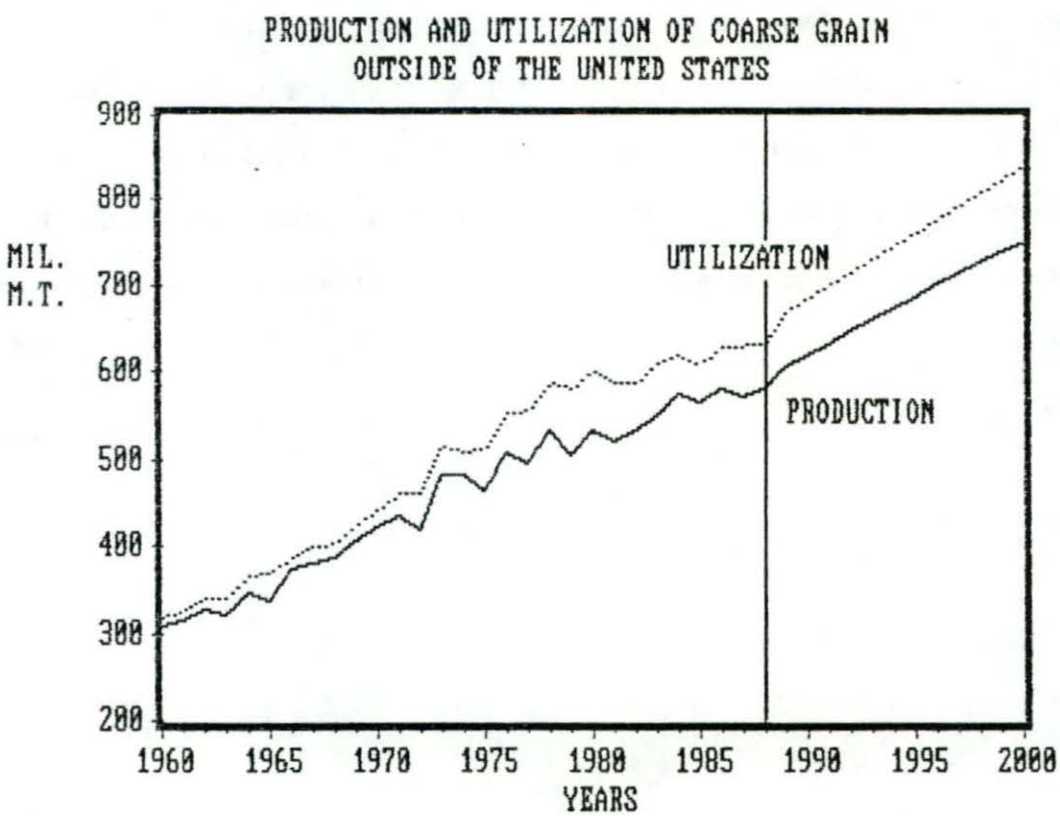


Figure 7

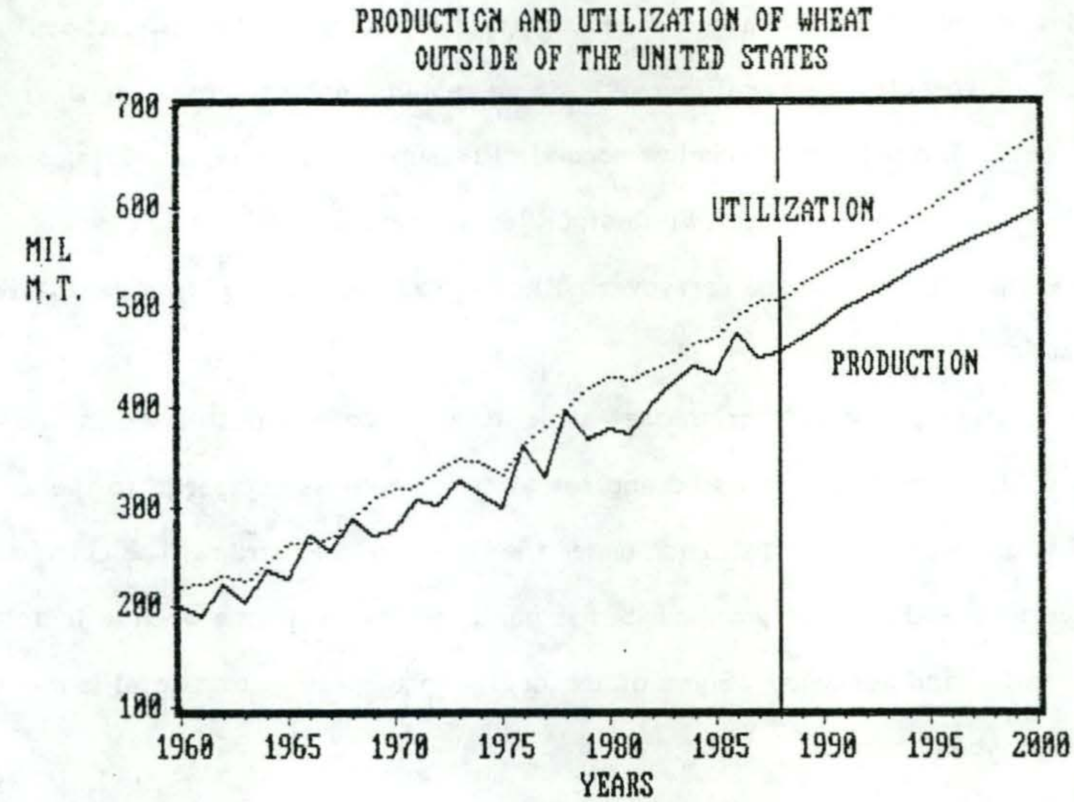
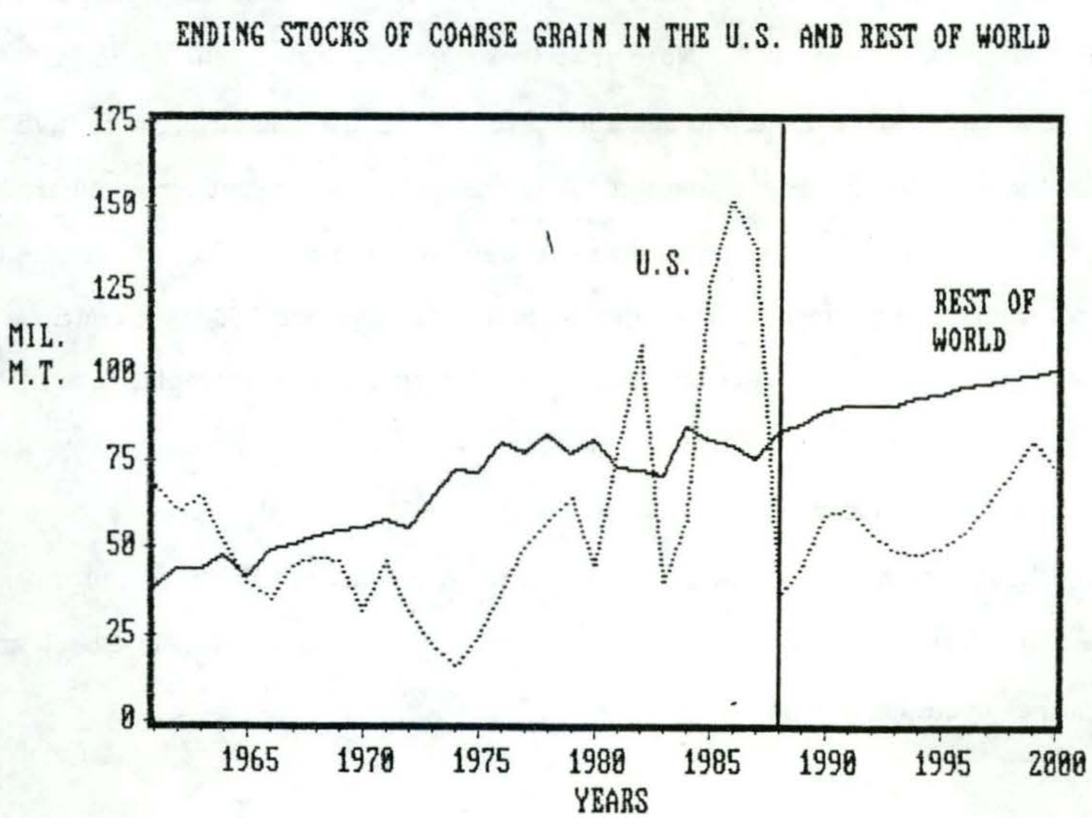


Figure 8



On wheat, carryover levels have dropped significantly outside of the U.S. as well as within, due to unfavorable weather (Figure 9). Some rebuilding is projected for the rest of the world, but U.S. stocks remain below normal. Pressures may develop to bring some land in the CR back into production. While stock levels are expected to increase abroad on both coarse grain and wheat, the carryover will continue to be on the low side relative to total utilization.

The substitution of the CR for the set-aside acres on corn is postulated in Figure 10. Charted is the total area harvested and set aside on corn as compared to the area harvested. The difference is the set-aside under the Feed Grain Program. The corn base which is entering the CR is not graphed, but is partly reflected in the decline in total corn land harvested and set aside. Some of the decline projected in that total is due to an expansion in soybean acres.

Profits in agriculture are highly volatile and tend to move in cycles. However, some consistency is noted over time and is a standard that can be used in judging how reasonable projections on prices and costs may be. This is illustrated in corn in Figure 11 which plots the gross margins over variable costs for participants and nonparticipants in the Feed Grain Program since 1960. Note that these gross margins, which are in 1967 dollars, have fluctuated around the \$50 per acre level. Note also the strong incentive to participate in the program in recent years and also the impact of the drought on margins in 1988. The projections point to margins well maintained in the mid 1990's in absence of a set-aside program. The pattern for margins to stabilize around the \$50 level continues.

Consistency in gross margins is also evident on livestock. For example, returns to hog producers are particularly volatile from year to year. Over time, however, an equilibrium level can be discerned as shown in Figure 12. The sharply higher feed prices in 1988 has pushed margins down near to historical lows, a situation likely to continue in 1989. Eventually, however, hog products will adjust output--probably will cut back too much and another cycle is launched.

Figure 9

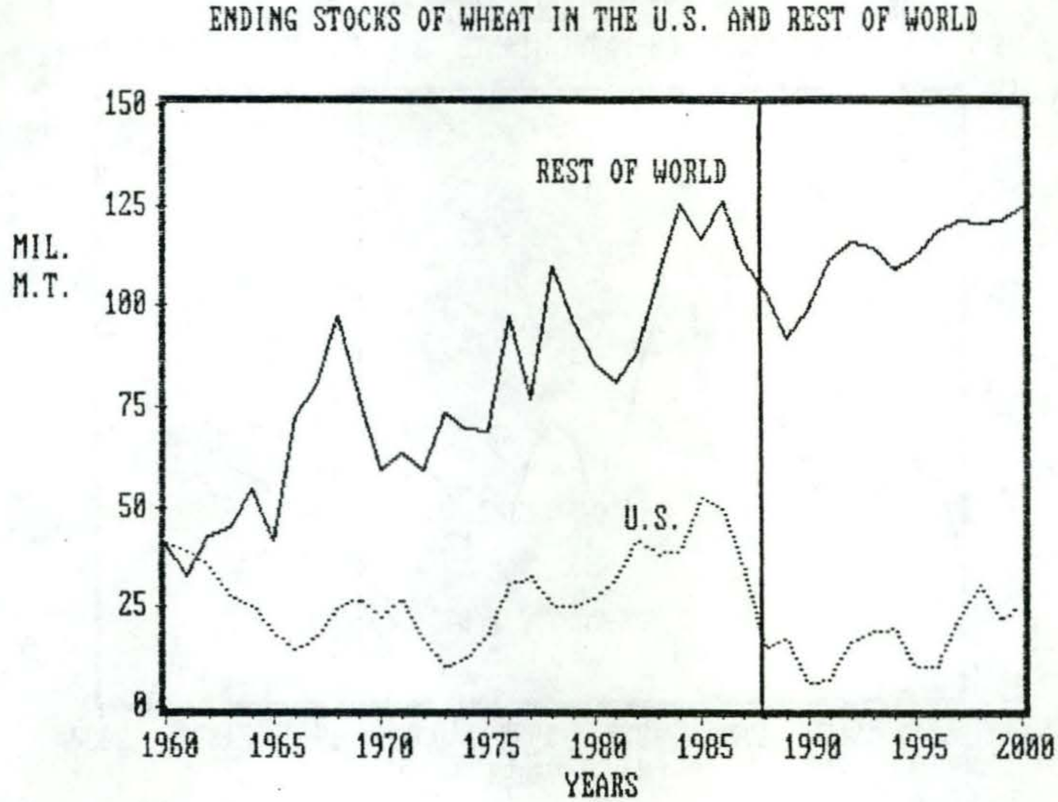


Figure 10

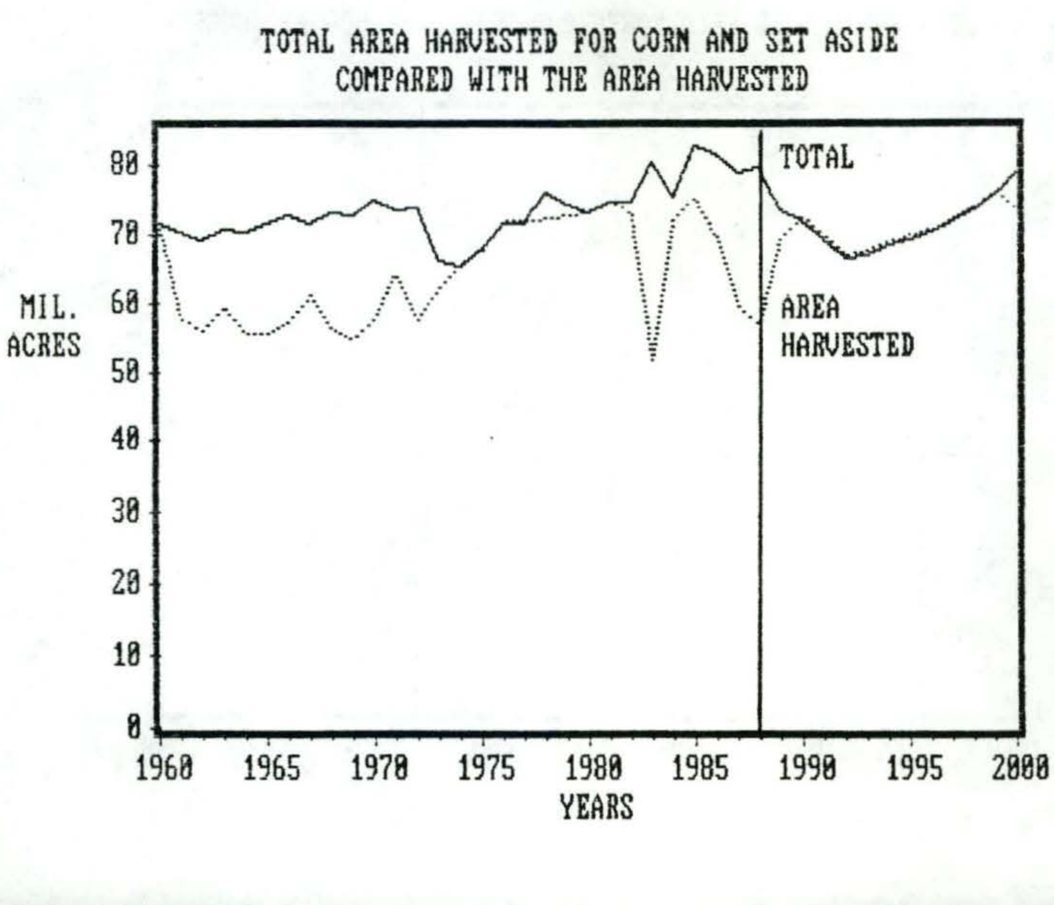
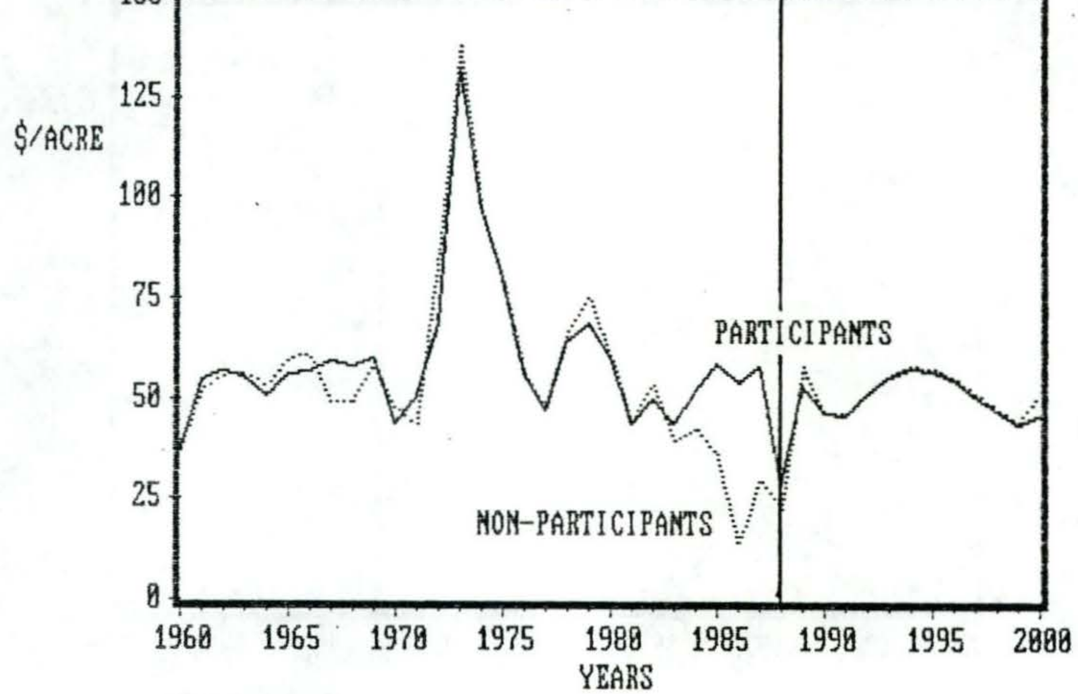


Figure 11

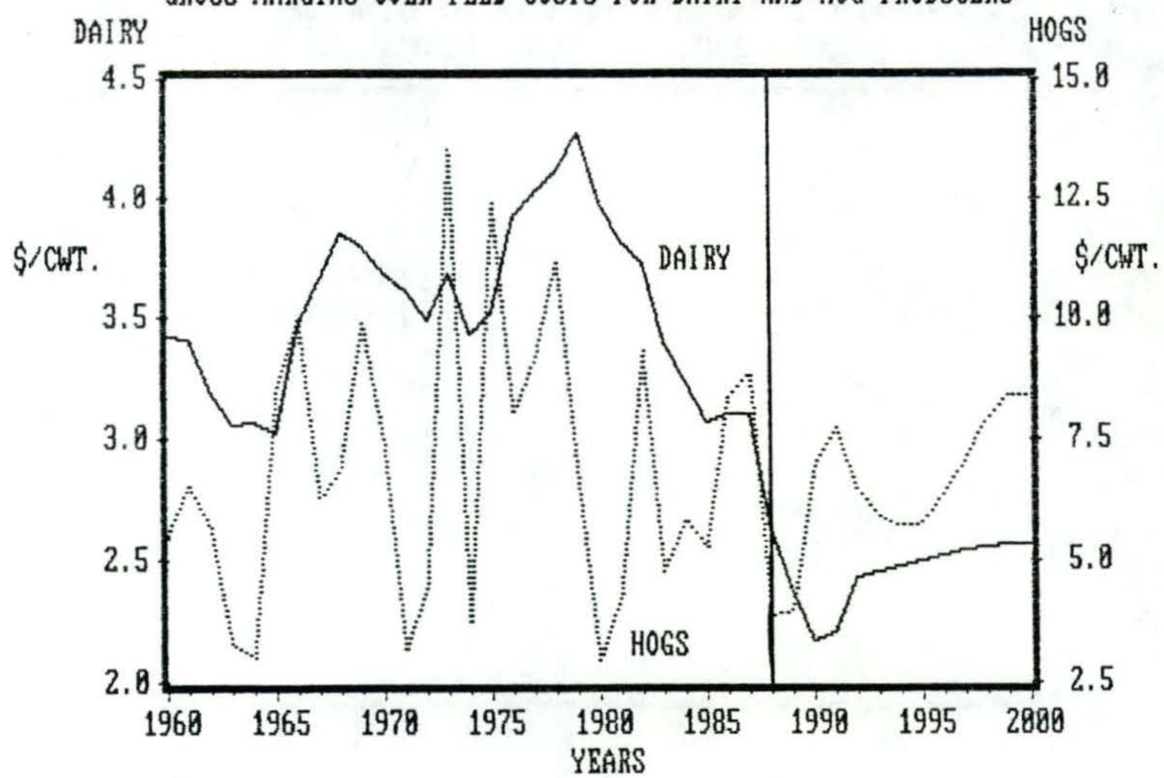
GROSS MARGINS OVER VARIABLE COSTS IN CORN PRODUCTION
FOR PARTICIPANTS AND NON-PARTICIPANTS IN THE FEED GRAIN PROGRAM*



*1967 DOLLARS

Figure 12

GROSS MARGINS OVER FEED COSTS FOR DAIRY AND HOG PRODUCERS*



*1967 DOLLARS

On the other hand, gross margins over feed costs in dairy, which have dropped sharply in recent years, may not spring back to the levels of the 1970's and early 1980's. As with hogs, the drought has triggered higher feed prices which will keep pressure on profits for another year or two. The projected departure of dairy returns from the patterns of the past is due to the predominance of the support program in establishing milk prices and the importance of fixed investment in dairy operations relative to other farm enterprises. The prospects are not strong that dairy support prices in real terms will be raised to levels of the past. Secondly, the rate of response in the dairy industry to lower returns has been fairly slow without special government programs.

The longer-term outlook for the livestock and meat industry is mixed. Even if the red meat industry succeeds in materially slowing down the downward shift in demand for their products, poultry meat and fish are likely to capture a larger share of the market in the coming decade (Figure 13).

The USDA has recently estimated net cash farm income to be $55-60 billion in 1988, about the same as in 1987. The drought, however, is likely to bring net farm income down about $6-7 billion from 1987 as the value of inventories drop at the end of the calendar year. AGMOD projects that net cash farm income will continue in the $55-60 billion range through much of the coming decade (in 1988 dollars).

If the projected growth in exports materializes, a base is established for a resumption in the long-term inflation in farm land values. As indicated in Figure 14, nominal land prices could reach the peak of the early 1980's. However, the real price is not expected to even approach the peak in the remainder of this century. If we could look into the next century, the response to this relatively favorable outlook for agriculture in the 1990's might bring some retrenchment in farm earnings and land prices, too.

Figure 13

CONSUMPTION OF BEEF, PORK, POULTRY MEAT AND SEAFOOD
PER CAPITA IN THE UNITED STATES

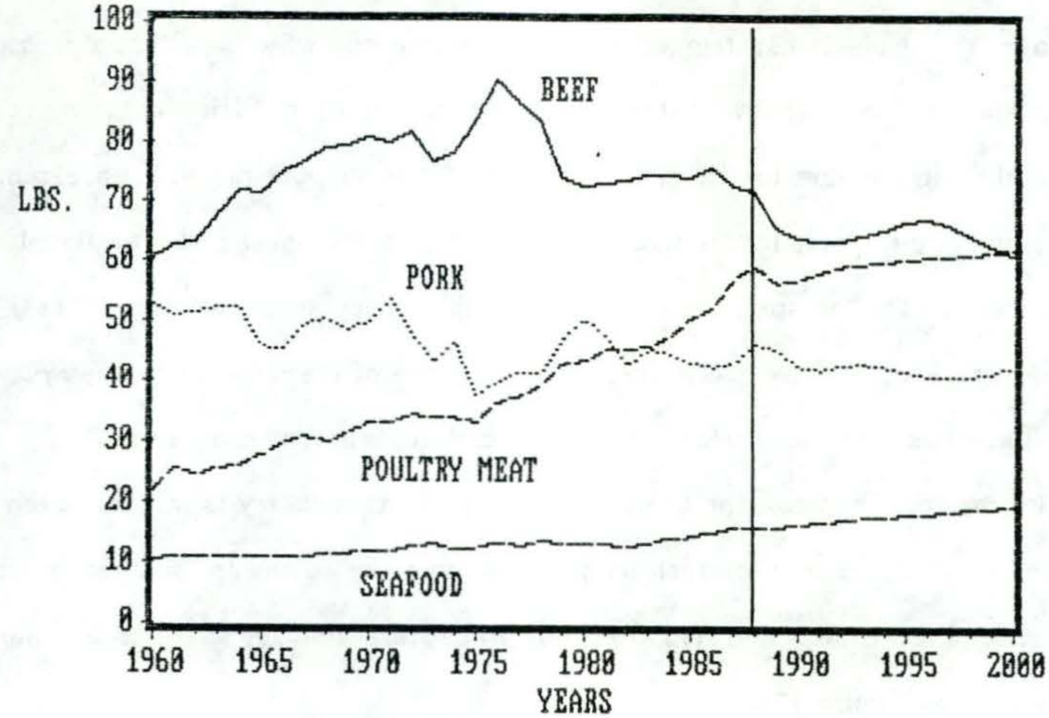
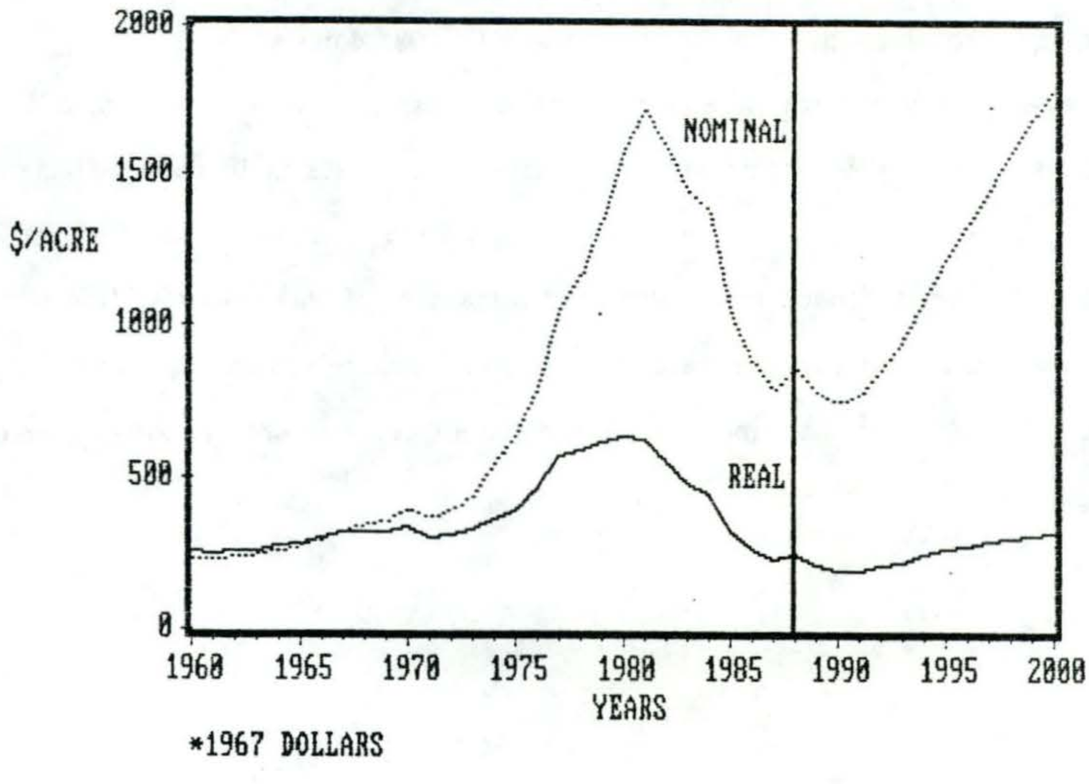


Figure 14

PRICE OF FARM LAND IN THE CORN BELT
IN NOMINAL AND REAL TERMS*



*1967 DOLLARS

References

Ferris, John. "A Scenario for Agriculture in the 1990's--Using 'AGMOD'." Agricultural Economics Staff Paper No. 87-98, Michigan State University, December 1987.

Ferris, John. "Long-Term Outlook for Michigan Agriculture and the Food Industry." Agricultural Economics Staff Paper No. 87-72, October 1987; Revised, March 1988.

Hall, Robert E. and David M. Lilien. Micro TSP User's Manual, Version 5.0. McGraw-Hill Book Company, New York, NY, 1986.

MSU Agriculture Model. "Long-Term Forecast of U.S. and World Agriculture." Department of Agricultural Economics, Michigan State University, Spring 1985.

Pindyke, Robert S. and Daniel L. Rubinfeld. Econometrica Models and Economic Forecasts, Second Edition. McGraw-Hill Book Company, 1981.

Shagam, Shayle. "An International Agricultural Trade Model With Linkage Capability." Volume I and Volume II. Unpublished M.S. Thesis, Department of Agricultural Economics, Michigan State University, 1987.

Shagam, Shayle and John Ferris. "Using Micro TSP With Mainframe Econometric Models." Computers in Agricultural Marketing. Proceedings of a Workshop sponsored by the North Central Computer Institute, October 13-15, 1986, Des Plaines, IL.

APPENDIX A

Endogenous Variable List for AGMOD [1/]

Domestic Livestock Sector

Code [2/]	Definition
NCWBF	Number of beef cows on farms, January 1 (1,000 head).
RPLCWF	Number of beef and milk cows replaced each year, (1,000 head).
QFBFF	Production of fed beef, carcass weight (million pounds).
QNFBDF	Production of nonfed beef, carcass weight (million pounds).
QBFF	Total beef production, carcass weight, including farm (million pounds).
BSMBFF	Base for calculating beef import quotas (million pounds).
NMBFF	Net imports of beef, carcass weight (million pounds).
SBFF	Total supply of beef, carcass weight (million pounds).
FWSF	Number of sows farrowing in the spring (1,000 head).
FWFF	Number of sows farrowing in the fall (1,000 head).
QPKF	Total pork production, carcass weight (million pounds).
QBRF	Total broiler production, ready-to-cook weight (million pounds).
QTKF	Total turkey production, ready-to-cook weight (million pounds).
QEGF	Total egg production, farm (million dozen).
NCWMF	Number of milk cows on farms, January 1 (1,000 head).
QMKCWF	Annual milk production per cow on farms, January 1 (1,000 pounds).
QMKF	Total milk production (million pounds).
SBFECF	Beef supply per capita, edible weight (pounds).
SPKECF	Pork supply per capita, edible weight (pounds).

1/ All livestock data are calendar year averages and all crop data are crop year averages unless otherwise noted.

2/ "F" at the end of code designates forecast values for the variables.

Code	Definition
QBRECF	Broiler production per capita, edible weight (pounds).
QTKECF	Turkey production per capita, edible weight (pounds).
CFSCF	Fish and seafood consumption per capita, edible weight (pounds).
QBFSCF	Beef substitutes available per capita, edible weight (pounds).
QPKSCF	Pork substitutes available per capita, edible weight (pounds).
QBRSCF	Broiler substitutes available per capita, edible weight (pounds).
QTKSCF	Turkey substitutes available per capita, edible weight (pounds).
QMTECF	Total red meat and poultry meat available per capita, edible weight (pounds).
QMKCF	Total milk production per capita (pounds).
QEGCF	Total egg production per capita (dozen).
PSRF [3/]	Price of Choice steers at Omaha ($/cwt.).
PBGF [3/]	Price of barrows and gilts at 7 markets ($/cwt.).
PBRF [3/]	Price of broilers, wholesale, 12 city (¢/pound).
PTKF [3/]	Price of turkeys, Eastern U.S., 8-16 pound young hens (¢/pound).
PFCVF [3/]	Price of 400-500 feeder steer calves at Kansas City, Medium, No. 1 ($/cwt.).
ILSPDF	Index of prices on livestock and poultry deflated by the Consumer Price Index ($/cwt.).
FPMKF [3/]	Price received by farmers for milk ($/cwt.).
FPEGF [3/]	Price received by farmers for eggs (¢/dozen).
GMCFDF	Gross margin on fed cattle over the cost of feed and feeder, deflated by CPI ($/cwt.).
GMHGDF	Gross margin on hogs over the cost of feed, deflated by CPI ($/cwt.).
GMBRDF	Gross margin on broilers over the cost of feed, deflated by CPI (¢/pound).

[3/] These variables are also deflated by the Consumer Price Index (CPI) and designated with a "D" just prior to the "F" or at the end of the code.

Cost	Definition
GMTKDF	Gross margin on turkeys over the cost of feed, deflated by CPI (¢/pound).
GMEGDF	Gross margin on eggs over the cost of feed, deflated by CPI (¢/pound).
GMMKDF	Gross margin on milk per cow over the cost of feed, deflated by CPI ($/head).
UFGLSF	Use of feed grain by livestock based on average feeding rates (million MT).
FPCADF	Price received by farmers for corn on a calendar year basis, deflated by CPI ($/bushel).
PSMADF	Price of soybean meal at Decatur, IL on a calendar year basis, 44% protein, deflated by CPI ($/ton).
VCCFDF	Variable cost for feeder and fed cattle feeding, deflated by CPI ($/cwt.).
FCHGDF	Cost of feed in farrow to finish operation, deflated by CPI ($/cwt.).
FCBRDF	Cost of feed in broiler operation, deflated by CPI (¢/pound).
FCTKDF	Cost of feed in turkey operation, deflated by CPI (¢/pound).
FCEGDF	Cost of feed in egg operation, deflated by CPI (¢/dozen).
FCMKDF	Cost of feed in milk production, deflated by CPI ($/cwt.).

Domestic Crop Sector

Code	Definition
YCNF	Trend yield on corn (bushels/acre).
YSBF	Trend yield on soybeans (bushels/acre).
YWHF	Trend yield on wheat (bushels/acre).
NCNDF	Gross margin on corn over variable costs, deflated by CPI ($/acre).
NSBDF	Gross margin on soybeans over variable costs, deflated by CPI ($/acre).
NWHDF	Gross margin on wheat over variable costs, deflated by CPI ($/acre).
FPPCNF	Price received by farmers for corn if prices are above the government loan rate, otherwise the government loan rate ($/bushel).
MCNF	Gross margin on corn marketed received by participants in the Feed Grain Program, over variable costs ($/acre).
PCNDF	Gross margin on corn over variable costs for participants in the Feed Grain Program, deflated by CPI ($/base acre).
NPCDF	Weighted average of gross margins on corn for participants in the Feed Grain Program and nonparticipants, over variable costs, deflated by CPI ($/base acre).
NPCSF	Weighted average of gross margin on corn for participants and nonparticipants in the Feed Grain Program and for soybean producers, over variable costs, deflated by CPI ($/base acre).
EFPCNF	Expected price received by farmers for corn if they participate in the Feed Grain Program ($/bushel).
EFPWHF	Expected price received by farmers for wheat if they participate in the Wheat Program ($/bushel).
ENCNDF	Expected gross margins on corn from the market, over variable costs, deflated by CPI ($/acre).
ENSBDF	Expected gross margins on soybeans from the market, over variable costs, deflated by CPI ($/acre).
ENWHDF	Expected gross margins on wheat from the market, over variable costs, deflated by CPI ($/acre).
EMCNF	Expected gross margins on corn from the market by participants in the Feed Grain Program, over variable costs ($/acre).
EMWHF	Expected gross margins on wheat from the market by participants in the Wheat Program, over variable costs ($/acre).

Code	Definition
EPCNDF	Expected gross margin on corn for participants in the Feed Grain Program, over variable costs, deflated by CPI ($/base acre).
DPMCNF	Difference for the gross margin on corn, over variable costs, between participants and nonparticipants in the Feed Grain Program.
PWHDF	Gross margin on wheat, over variable costs, for participants in the Wheat Program, deflated by CPI ($/base acre).
EPWHDF	Expected gross margin on wheat for participants in the Wheat Program, over variable costs, deflated by CPI ($/base acre).
DNPWHF	Difference for the gross margin on wheat, over variable costs, between participants and nonparticipants in the Wheat Program.
ENPCDF	Weighted average of expected gross margins on corn for participants in the Feed Grain Program and nonparticipants, over variable costs, deflated by CPI ($/base acre).
TACSSF	Total area harvested for corn and set-aside plus area harvested for soybeans (million acres).
RCATF	Ratio between area harvested for corn and set-aside to TACSSF.
TACSAF	Total area harvested for corn and set-aside (million acres).
RHTCNF	Ratio between area harvested for corn and TACSAF.
AHCNF	Area harvested for corn (million acres).
AHSBF	Area harvested for soybeans (million acres).
ENPWDF	Weighted average of expected gross margin on wheat for participants in the Wheat Program, and nonparticipants, over variable costs, deflated by CPI ($/base acre).
TAWSAF	Total area harvested for wheat and set-aside (million acres).
RHTWHF	Ratio between area harvested for wheat and TAWSAF.
AHWHF	Area harvested for wheat (million acres).
RPTWHF	Ratio of total area harvested for wheat and set-aside that is in the Wheat Program relative to TAWSAF.
ASAWHF	Area set-aside in Wheat Program (million acres).
RADRCF	Ratio between the percent of corn base in the set-aside and the set-aside rate.
RPTCNF	Ratio of total area harvested for corn and set-aside that is in the Feed Grain Program relative to TACSAF.

Code	Definition
ASACNF	Area set-aside for corn in the Feed Grain Program (million acres).
QCNF	Production of corn (million bushels).
QSBF	Production of soybeans (million bushels).
QWHF	Production of wheat (million bushels).
QFGF	Production of feed grain (million MT).
XFGF	Exports of feed grain (million MT).
XWHF	Exports of wheat (million bushels).
XSBF	Exports of soybeans (million bushels).
UFGFDF	Utilization of feed grain for feed (million MT).
UFGNFF	Utilization of feed grain for food, seed, and industrial purposes (million MT).
UWHCCF	Utilization of wheat for food per capita (bushel).
UWHCF	Utilization of wheat for food (million bushels).
RPWCAF	Ratio between the season average farm price of wheat and the calendar year average farm price of corn.
FDWHF	Quantity of wheat fed to livestock (million bushels).
USMFDF	Utilization of soybean meal by livestock (million MT).
CRSBF	Crush of soybeans (million bushels).
UFGF	Total utilization of feed grain (million MT)
UWHF	Total utilization of wheat (million bushels).
USBF	Total utilization of soybeans (million bushels).
ESTFGF	Ending stocks of feed grain (million MT).
ESTWHF	Ending stocks of wheat (million bushels).
ESTSBF	Ending stocks of soybeans (million bushels).
SUFGF	ESTFGF/UFGF.
SUWHF	ESTWHF/UWHF.
SUSBF	ESTSBF/USBF.

Code	Definition
FPCNF 4/	Price received by farmers for corn ($/bushel).
FPWHF 4/	Price received by farmers for wheat ($/bushel).
FPSBF 4/	Price received by farmers for soybeans ($/bushel).
PSMF 4/	Price of soybean meal, 44% protein, at Decatur, IL ($/ton).
PSOF 4/	Price of soybean oil, Decatur, IL (¢/pound).
DRCN	Set-aside requirement for corn in the Feed Grain Program as a percent of base (percent).
DVRCN	Paid diversion for corn in the Feed Grain Program as a percent of base (percent).
DRWH	Set-aside requirement for wheat in the Wheat Program as a percent of base (percent).
DVRWH	Paid diversion for wheat in the Wheat Program as a percent of base (percent).
NPNLC	Net return over variable and fixed nonland costs for corn producers, weighted by participants and nonparticipants in the Feed Grain Program ($/base acre).
NNLS	Net return over variable and fixed nonland costs for soybean producers ($/acre).
NNLCS 4/	Net return over nonland costs for corn and soybeans in the Corn Belt ($/base acre).
PLCBF 4/	Average price of farmland in the Corn Belt, simple average for MN, MO, IO, IL, IN, and OH ($/acre).

4/ These variables are also deflated by the Consumer Price Index (CPI) and designated with a "D" just prior to the "F" or at the end of the code.

International Crop Sector

Code	Definition
YFGOF	Yield of coarse grain outside of U.S. (MT/hectare).
YFGOF	Yield of wheat outside of U.S. (MT/hectare).
ERGRXF	Expected real gross returns from coarse grains and wheat per hectare in major exporting nations.
RFGODF	Expected real gross returns from coarse grains per hectare outside of U.S. ($/hectare).
RWHODF	Expected real gross returns from wheat per hectare outside of the U.S. ($/hectare).
ERGOXF	Weighted average of expected gross returns from coarse grains and wheat per hectare outside of the U.S. and major exporting nations ($/hectare).
HAGRXF	Area harvested for grain in major competing export nations (million hectares).
HAGOXF	Area harvested for grain outside of U.S. and major competing export nations (million hectares).
HAGROF	HAGRXF + HAGOXF
RRFWOF	Expected real gross returns from coarse grains per hectare outside of U.S. divided by the expected real gross return from wheat per hectare outside of U.S.
RHAFOF	Ratio between area harvested for coarse grain outside of U.S. and total area harvested for grain outside of U.S.
HAFGOF	Area harvested for coarse grain outside of U.S. (million hectares).
HAWHOF	Area harvested for wheat outside of U.S. (million hectares).
QFGOF	Production of coarse grain outside of U.S. (million MT).
QWHOF	Production of wheat outside of U.S. (million MT).
UFGOCF	Utilization of coarse grain per capita outside of U.S. (million MT).
UWHOCF	Utilization of wheat per capita outside of U.S. (MT).
UFGOF	Utilization of coarse grain outside of U.S. (million MT).
UWHOF	Utilization of wheat outside of U.S. (million MT).
DFFGOF	Difference between production and utilization of coarse grain outside of U.S. (million MT).

Code	Definition
DFWHOF	Difference between production and utilization of wheat outside of U.S. (million MT).
ESTFOF	Ending stocks of coarse grain outside of U.S. (million MT).
ESTWOF	Ending stocks of wheat outside of U.S. (million MT).
SUFGOF	ESTFOF/UFGOF.
SUWHOF	ESTWOF/UWHOF.
SUGROF	(ESTFOF + ESTWOF)/(UFGOF + UWHOF).
HASABF	Area harvested for soybeans in Argentina and Brazil (1,000 hectares).
EGSABF	Expected real gross returns from soybeans per hectare in Argentina and Brazil ($/hectare).
PSABDF	Real price of soybeans in Argentina and Brazil ($/bushel).
PFABDF	Real price of corn in Argentina and Brazil ($/bushel).
YSABF	Yield of soybeans in Argentina and Brazil (MT/hectare).
QSABCF	Production of soybeans per capita in Argentina and Brazil (MT).
CMABCF	Consumption of soybean meal per capita in Argentina and Brazil (MT).
DSABF	Difference between production of soybeans and consumption of meal in soybean equivalents, Argentina and Brazil (million bushels).
DSABCF	DSABF divided by the population outside the U.S. (bushels per capita).

APPENDIX B

Exogenous Variable List for AGMOD [1/]

Code	Definition
TIME	Serial time, i.e., 1960=1960, 1961=1961, etc.
TO76	Years tabulated in terms of minus years to 1976 and zero in 1976 and afterward.
AFT76	Years tabulated in terms of plus years after 1976 and zero in 1976 and before.
AFT76D	Same as AFT76 except that values increase at a decreasing rate after 1987.
NMPK	Net imports of pork, carcass weight (million pounds).
POPC	Civilian population of the U.S. (million).
POPO	Population outside of the U.S. (million).
POPAB	Population of Argentina and Brazil (million).
DICD	Disposable income per capita deflated by CPI ($).
CPI	Consumer Price Index (1967=1.000).
IRLB	Interest rate charged new borrowers at the Federal Land Banks (%).
GPOCDF	Gross National Product per capita in real terms outside of the U.S. ($).
GPABD	Gross National Product per capita in real terms in Argentina and Brazil ($).
CVPSAB	Weighted average real exchange rate for Argentina and Brazil, based on soybean production (1980=1.000).
SPMK [1/]	Support price on manufacturing milk, calendar year average ($/cwt.).
XRCNM2	Export weighted exchange rate on corn, U.S. markets, average for years t and t+1 (1980=1.000).
XRSBM2	Export weighted exchange rate on soybeans, U.S. markets, average for years t and t+1 (1980=1.000).

[1/] These variables are also deflated by the Consumer Price Index (CPI) and designated with a "D" at the end of the code.

Code	Definition
XRWHM2	Export weighted exchange rate on wheat, U.S. markets, average for years t and t+1 (1980=1.000).
LRCN 1/	Loan rate on corn ($/bushel).
TPCN	Target price on corn ($/bushel).
PYCN	Program yield on corn (bushel).
DVPCN	Diversion payment rate on corn ($/bushel).
VCDA	Variable cost for maintaining set-aside and diverted acres ($/acre).
LRWH 1/	Loan rate on wheat ($/bushel).
TPWH	Target price on wheat ($/bushel).
PYWH	Program yield on wheat (bushel).
DVPWH	Diversion payment rate on wheat ($/bushel).
VCCN	Variable cost of production on corn including interest on operating capital and an allowance for unpaid family labor ($/acre).
VCSB	Variable cost of production on soybeans including interest on operating capital and an allowance for unpaid family labor ($/acre).
VCHW	Variable cost of production on hard red winter wheat including interest on operating capital and an allowance for unpaid family labor ($/acre).
FNLCCN	Fixed nonland costs of production on corn ($/acre).
FNLCSB	Fixed nonland costs of production on soybeans ($/acre).
YCN	Yield on corn (bushel/acre).
YSB	Yield on soybeans (bushel/acre).
YWH	Yield on wheat (bushel/acre).
CFFGX	Index of real exchange rate in major exporting nations times trend yield on coarse grain, weighted by area harvested.
CFWHX	Index of real exchange rate in major exporting nations times trend yield on wheat, weighted by area harvested.