A SIMULATION MODEL OF UNITED STATES AGRICULTURE

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ABSTRACT

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U.S. agriculture operates within a turbulent environment, subject to price and income volatility, vulnerable especially to resource constraints and changes in policies of monetary, international trade and geopolitical relations. The objective was to develop a supply, demand and policy framework of the U. S. domestic grain, oilseed and livestock sectors. The departure of this research from previous U.S. agriculture sector modeling is in the exercise of identifying the integral nature of U.S. agricultural commodity policy within a supply and demand framework.

The model is a multi-commodity, multi-period descriptive non-optimizing simulation framework. The specific objective of the model is to assist in analyzing and projecting the intermediate to long-term effects of the changing environment on U.S. agriculture. The simulation framework is based primarily upon econometrically estimated equations of supply, demand, price and policy relationships. The structure of the model is characterized as a set of integrated commodity models with three important sets of linkages: 1) feedgrain livestock, 2) crop supply, demand and policy management, and 3) domestic-international grain markets. The crop sector is disaggregated into wheat, corn, sorghum, barley, oats, and soybeans. The livestock component has separate sectors for beef, dairy, pork, and poultry. The policy framework identifies both supply and demand management policy interactions. Supply management recognizes the role of loan rates, target prices, set-asides, national program acreage, diversion payments, and recommended voluntary diversion. Demand management identifies the Commodity Credit Corporation stocks and farmer-owned reserve stocks rules and their relationships to the supply control variables. The domestic-international linkage is based upon export supply available from domestic production and grain prices received by farmers which are derived from export prices. Equation estimates are presented for endogenous variables in the domestic component of the model. Numerous hypotheses especially dealing with supply models are investigated.

The policy framework which endogenizes the farm commodity programs is described. Comparisons of actual and ex ante forecasts of the major model variables are evaluated for the period 1980 through 1982. Further study on estimation and explanation of policy response is needed. The uncertainty which dominates the agricultural policy environment necessitates that analyses be couched in probabalistic simulations.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF FIGURES

CHAPTER I

Introduction

Justification

The U.S. farm sector has experienced turbulent times over the most recent decade, 1970-80. In constant dollars, net income to farm operators increased from $12.4 billion in 1970 to $17.3 billion in 1974. It then declined to a level of $11.4 billion in 1976 and $11.0 in 1977. Farm income rebounded to $14.3 and $15.3 billion in 1978 and 1979, respectively - - - but declined sharply in 1980 below $10 billion.

Much of the higher income levels in the early 1970's resulted from grain price increases caused by worldwide crop production shortfalls, to some extent accentuated by purchasing behavior of some state trading companies. However, the high grain and oilseed prices which translated into handsome incomes for cash grain farmers placed substantial pressures upon the livestock economy. The beef cattle sector faced triple jeopardy since it was in the expansion phase of the cattle cycle, faced high grain prices and experienced poor pasture condition due to drought. The impacts of excessive supplies and unexpectedly high feed prices led to losses by both feedlot operators and cow-calf producers. The result was a liquidation of the national cow herd of unprecedented magnitude and duration. The dairy sector was similarly affected. In contrast, pork and poultry producers, capable of faster production adjustment, contracted supplies sufficiently to generate high product prices and record rates of profitability.

Over the second half of the decade, circumstances changed. As a result of the sustained liquidation, the beef and dairy producers faced very favorable product prices and experienced positive returns. On the other hand, increasing rigidity in the supply adjustments in the pork and poultry sectors led to less favorable prices and returns. Successive years of normal worldwide grain production led to relatively lower cash grain prices.

These major price and income swings coupled with steadily rising production costs led to substantial political activity by new farm groups such as the American Agriculture Movement as well as by established farm organizations such as Farm Bureau in supporting various kinds of supply controls and grain reserve strategies. In addition to the concern for price and income stabilizing policies, the policy agenda began to focus upon the basic structural aspects of the U.S. farm sector. Important structural dimensions of the farm sector include the trend towards fewer and larger farms of increasing specialization, and growing dependence upon energy-intensive purchased inputs and capital investments. The rapid rise in real energy prices coupled with the recent monetary policies of credit restraint have placed a significant burden of adjustment upon the farm production sector. It is becoming increasingly clear that the U.S. farm production system is extremely vulnerable to both higher energy prices and credit restraints.

Throughout this same period, the volatility in farm prices was transmitted into food prices which motivated consumer sensitivity to the whole set of food and farm price issues. The price increases of agricultural commodities in the early 1970s were a significant manisfestation of the general economy's inflationary spiral. Today food prices invariably are highlighted in reports on the Consumer Price Index. There are now escalator clauses in a number of wage contracts and federal government transfer programs are tied to the Consumer Price Index. Thus, food price behavior has a substantial indirect, as well as direct impact on the entire economy. With progressively increased processing of food products and away-from-home food consumption, the farm sector has become more interdependent with the rest of the U.S. economy. Finally, the farm sector has become increasingly tied to the world food economy. With an ever increasing volume and value of agricultural exports, the U.S. agricultural producers have tended to become more interdependent with the rest of the world.

The scope and complexity of these issues and circumstances has been and will continue to be a tremendous challenge for agricultural policy analysis and decision-making. The implications for research are clearly directed at developing an understanding of these complex relationships and the nature of their uncertainty.

A fruitful way to deal with the highly complex, interrelated aspects of U.S. agriculture and government policy is to work in the context of an agricultural sector model. Simple deterministic commodity models are no longer adequate analytical frameworks for investigating these relationships and problems. The development of powerful quantitative analytical techniques and computer hardware can provide the kind of complex analytical framework needed.

Objective

The objective of the research documented in this study was to develop a model of the U.S. livestock, feed and food grain sectors. This is a contribution to a larger and on-going modeling exercise of the Michigan State University Agriculture Model. The MSU Agriculture Model has been developed to provide a multi-faceted analytical framework about the U.S. and international grain and livestock economies. It is a descriptive non-optimizing set of interrelationships which generates annual forecasts of production, utilization and prices.

At the initiation of the research reported here, an existing national agricultural sector model originally developed by Trapp, McKeon, and Hondai (1976), had many of these major specification features.

The three basic components of the model were:

1) a domestic supply component to project production of wheat, feed grains (corn, sorghum, barley, and oats) oilseeds, fed beef, non-fed beef, pork, poultry and dairy products.

2) a domestic demand component to project demand for each of the above commodities and;

3) an international trade component to project U.S. exports of wheat, feed grains and oilseeds.

A critical review of the original specification and estimates suggested that nearly all of the equations were in need of updating and reestimation.

This was given further emphasis due to the major data series revisions (in many series as far back as 1970) of the USDA Agricultural Statistics, which is the basic source for the model data bank. Objections with the specifications were based upon both conceptual and empirical performance of the various model components.

A particular concern of this research was the need to identify the integral nature of agricultural policy within the supply and demand framework. Policy has been an important influence in U.S. agriculture. The level of income support to farmers, the degree of price variability, the integration of supply and demand management as well as structural change in the agriculture sector dominate the policy agenda confronting decision-makers and analysts. A research framework which reflects the complexities and breadth of these policy issues is desirable in order to evaluate the impact of changes in policy. This framework must be sufficiently general such that alternative policies can be readily evaluated. On the other hand, the identification of how the policy impacts upon the farm sector and vice versa, can not be treated superficially. For this reason the policy process has been modeled as an endogenous component to the framework. This does not pre-empt the capability or usefulness of exogenously adjusting or controlling policy parameters.

The impact of alternative policies upon the farm sector cannot be analysed unless one has a comprehensive and validated description of the farm sector itself. Thus, while the model is designed to facilitate policy analysis, considerable effort and attention has been given to the identification and estimation of the supply and demand framework, integrating conceptual, empirical and analytical issues for each commodity.

Dissertation Organization

General methodological issues are discussed in Chapter II. The supply and demand framework is developed in Chapter III. The policy framework is presented in Chapter IV. Chapter V presents a discussion of the usefulness of quantitative models in the policy process, the potential and limitations of the MSU Agriculture Model, and a suggested framework for analysing the issues of grain reserve management and its relationship to supply management. The final chapter summarizes the study and draws conclusions about the research results and suggestions for future development and model needs.

CHAPTER II

Methodology

No attempt will be made to review the accumulated body of knowledge with regard to the many theoretical underpinnings of this modeling effort. Throughout the discussion of the model structure, many of these will be identified. The objective of this chapter is to recognize important aspects of the research approach by which the modeling exercise has been guided.

The General Research Approach

The modeling effort can be described as having followed a systems approach. The systems methodology is essentially a problem-solving procedure which need not rely upon any one analytical technique or discipline. The most important aspect of this approach is that it allows for a research process which evolves and iterates, to develop a set of interconnected elements designed to contribute to problem solutions. The MSU Agriculture model has, since its origin, drawn heavily from economic theory and econometric techniques. It does so in its current state; however, methodology has evolved and will continue to evolve over time in response to changing needs and problems. The introduction of biological, policy and other types of information and the use of non-econometric techniques have resulted in a model with broader scope and capacity to contribute to our understanding of a greater array of problems.

The objectivity of this model research has been tested with regard to the criterion of internal consistency which requires conformance to logic and coherence. It has been tested with regard to its correspondence with the real world it is designed to portray, through the use of formal and informal statistical tests. Its clarity, consistency and coherence have been tested by continual review and interaction with the faculty and staff in the Department of Agricultural Economics and interested users in government and industry. Finally it has been tested in terms of its capacity to contribute to an understanding of actual problems and solutions.

The methodological objective of this research was to avoid the use and development of overpowering techniques. Economic and statistical theories useful in designing analytical frameworks of U.S. agriculture have long been developed and shown to be useful, (Martin, 1977). The aim was then to use these rather standard analytical techniques to establish objectivity in our ability to study policy problems, their possible solutions and the impact upon the various interdependent subsectors in the agricultural economy.

The Framework Necessary for Analysis of Grain Reserve Programs

A major problem for policy analysis of the grain reserve issue is not necessarily in developing programs, but rather in the need to consider the feasibility of implementing and understanding the linkages associated with the existing programs. Previous research has focused dominantly upon the question of optimal size and welfare implications. Few studies had attempted to assess the feasibility or problems of implementation, its interdependence with other policy objectives and programs and its interaction with an integrated food and farm sector with particular concern for the livestock and export linkages.

It was determined that the MSU Agricultural model contained a reasonable framework to facilitate the analysis of this problem. The emphasis was to modify the existing MSU Agricultural model in order to examine the specific policy issue of integrating the grain reserve management program with commercial U.S. agricultural policy.

The suitability of this model rested upon the ability to project the U.S. agricultural sector thru time within a policy framework. In order to accomplish this, the model must identify the important participants, commodities and policy rules and responses. It must be able to anticipate the behavior or response of both crop and livestock of farmers in their supply of commodities in terms of alternative open market prices and alternative government programs. It must be capable of predicting how the exporting/importing nations will respond to different export offer prices and policies which impact upon the exports or imports of any one trading country. Finally the model must be capable of identifying a U.S. policy framework which not only impacts upon the agriculture sector but responds in reasonable and predictable ways to the events and time path of foreign and domestic agriculture. The most fruitful way to deal with the highly complex, interrelated aspects of U.S. agriculture and government policy is to work in the context of an agricultural sector model.

The Michigan State University Agricultural Model as developed by Trapp and others fortunately included many of these major features. Econometric equations had been estimated for each of the three major components of the model and an integrated econometric simulation model was currently operational.

In order to facilitate the policy problem-solving framework it was necessary to model the reserve programs as a component. Further, the government supply management policies were originally treated strictly by a set of exogenous assumptions. It was seen as useful to endogenize as much of the policy process as possible such that projections of production, consumption and prices could interact with likely government responses. It has already been indicated that the entire domestic supply and demand components were re-estimated and respecified. The respecifications will be presented in the discussion of the model structure. It was necessary as well that the model be able to summarize the result or performance in terms of a common denominator such as income. An economic and financial projections model of the U.S. farming sector has been developed at Michigan State University independent of the MSU Agricultural Model, Baker (1978). It was determined that these models could usefully complement one another by integrating the two.

The supply-demand framework in the economic and financial projections model were highly aggregated into two commodities: crops and livestock; exports, government payments and other items were essentially tracked exogenously. These are the variables which the MSU Agricultural Model has endogenized in considerable detail. On the other hand, the financial framework has a farm cost sector, flow of funds and an income accounting and balance sheet framework which were important missing elements in the MSU agriculture model. Therefore the integration of the two models is conceptually and empirically useful.

The final component of the model in terms of the framework necessary to analyze the efficiency of the integration of supply and demand management is a stochastic framework. In order to identify the interaction of alternative management with a projection of agricultural supply and demand, the empirical approach using deterministic solutions is useful but inadequate given the uncertain environment in which the policy framework operates. Given that the essence of the reserve stocks issue is the recognition of the uncertainty of production levels, related largely to yield variability, it is necessary to set the model within a stochastic framework which reflects as well as possible this uncertainty.

The full system thus in general is identified by five basic components which are interdependent. It includes:

1) a U.S. supply and demand component
2) an international export supply and import demand component
3) a U.S. agricultural policy component
4) a U.S. income accounting and flow of funds component
5) a stochastic simulation framework

Specification of the Model

As an abstract representation of the real world, this or any model is necessarily subject to a degree of aggregation. In the process of abstracting the essential interconnected elements of the U.S. agriculture sector considerable aggregation is necessary. Choice of the degree of aggregation over time, space, product and type of producer/consumer was consciously made.

Temporal Dimension

Most agricultural sector models are either annual or quarterly in the time dimension. The MSU Agricultural Model is an annual model. This specification depends upon the purpose for which it has essentially been structured. Since the inception of the MSU Agricultural Model, a clientele need was perceived for projection of the U.S. agriculture sector into the intermediate future of 3 to 5 years. Thus the model was designed to abstract from the seasonal aspects within the year in order to identify the dynamics of adjustment into a longer run. Length of run for adjustment is of course, commodity specific when we consider up to 5 years for the cattle industry and less than a year for certain poultry outputs. It is however important to recognize that the model output can be biased because it ignores short-run or seasonal phenomena.

A completely separate aspect of the time aggregation relates to the issue of the particular time series selected for estimation purposes. Parameter estimates generated by different sample periods may be substantially different because the structural relationship between the dependent and explanatory variable is subject to change over time.

An important assumption of time-series analysis common in this model is that the relationship between the dependent and explanatory variables have not changed over the estimation period and will not over the prospective forecast period. With this assumption, there is obviously a need to select a sample period as homogenous with respect to the structural relationship. A shorter time series generally is one straight-forward way to enhance the homogeneity aspect. Various F statistics (e.g., Chow-test) can indicate statistically significant differences in parameter estimates based upon alternative sample periods.

They were used in this study when the sample period appeared to be an important issue. On the other hand, fewer observations mean fewer degrees of freedom. These are the two important countervailing constraints upon sample period choice. In this study the sample period for each commodity was considered independently. The respective estimation periods are identified in the presentation of the empirical model. It should be noted before concluding this discussion that varying parameter techniques have been developed by which changes in structural relationships over time can be identified (Maddala). The more conventional technique employed in this research either assumes no change in structural relationships over the estimated period or introduces explicity, proxy variables such as time or other dummy non-stochastic variables which accomodate our ignorance and inability to identify time-varying structural relationships.

Spatial Dimension

The specification of this model abstracts from regional or state distinctions. The production system specified in this model is far from homogenous over the entire U.S. Major differences in enterprise combination, size of operation, and relative importance of costs are known to exist. Aggregation over space limits the consideration of questions which are regional by nature (e.g., changes in geographical location in response to changes in comparative advantage and geographical specialization).

Structural Dimension

The aggregation of national data abstracts from the individual producer. Substantial differences exist among producers of any one commodity in relation again to such aspects as enterprise alternatives, level of concentration, and relative cost structures. Again this model is limited in its ability to contribute to problems of structural changes in the industry structure which are essentially micro level adjustments such as the development of enterprise specialization, producer concentration, or vertical integration.

Commodity Dimension

Significant differences exist in wheat type produced in the U.S. There are five major classes: hard red winter, soft red winter, hard red spring, durum and white wheat. Production, price levels and movement, and utilization of these types are not homogenous. Nevertheless this model aggregates them and is not useful in contributing to detailed issues which relate to differences by class. As with wheat every other commodity in the model is aggregated in varying degrees. This model was not designed to be a collection of exhaustive commodity models. The degree of aggregation by commodities represents an economic choice influenced by the ability and cost of computer solution, the amount of research effort necessary to estimate and maintain a more detailed model, the ability to manage in a problem solving format the model output, and ultimately the demand for commodity specific model output. These considerations which concern the economics of model design are applicable to every aspect of a modeling exercise. Once a model is specified it is important however to take stock of its limitations relative to alternative model specifications. A systems research approach recognizes that this important aspect of research design is ultimately a function of the changing research needs which require a constantly evolving model specification.

General Statistical Considerations

As stated earlier, most of the empirical relationships in the MSU Agricultural Model are econometrically estimated. Every structural equation except for identities represent an attempt to explain how the endogenous variables change from year to year. The explanation by each equation is inexact; the statistical model of the unexplainable part is aggregated into a single stochastic disturbance term, U_t. Standard assumptions about the statistical nature of U_t are made. The probability distribution of U_t is assumed to be the same over the sample time series. The nature of the probability distribution of the U_t is not investigated in detail. They are generally assumed to be distributed normally with zero mean and a known finite variance. This assumption relies heavily upon the asympotic implications of the Central Limit Theorem.

The estimation problem involves the determination of the functional relationships of the U_t to the endogenous variables given the observations on the predetermined (exogenous and lagged endogenous) variables. Since the nature of the U_t distribution is assumed, the "maximum likelihood" structural parameter estimates are derived by maximizing the probability density function of the conditional distributions for the endogenous variables.

The choice of the actual method of estimation for any system of equations ought to reflect the nature of the simultaneous relationships among the endogenous variables. The choice made for the MSU Agriculture Model was ordinary least squares (OLS). This estimating technique is generally unsatisfactory for a general simultaneous equation model. OLS

estimates will be both biased and inconsistent, since if there is more than one endogenous variable in the equation, i.e., one in addition to the dependent variable, then this explanatory endogenous variable will generally be correlated with the disturbance term, U_t. However, the MSU Agriculture Model is in large measure a recursive model. A recursive system is the only type of model for which OLS estimators are optimal. The basic aspects of the OLS technique include 1) estimating each structural equation independently, 2) ignoring restrictions on equations other than the one being estimated, 3) assuming that it is possible to express each endogenous variable in reduced form.

The recursiveness of the MSU Agriculture Model is in part based upon the so-called "cobweb" model of agricultural systems, where supply is pre-determined. Demand responds to current information, including quantity supplied. If additionally the variance-covariance matrix of the structural disturbances is diagonal, then the OLS method leads to consistent and asymptotically efficient estimates. The estimates are also unbiased if no lagged dependent variables are used as explanatory variables. The MSU Agricultural Model specification does not fully meet all of these conditions. In general, there is simultaneity among the endogenous demand variables, across commodities and source (food, livestock, feed, and export) of demand. Aspects of recursiveness and simultaneity will be presented in greater detail in the chapter on model structure.

Despite the fact that this model is less than fully recursive, and therefore at least some of the estimates are inconsistent and biased, several issues should be noted. The OLS method compares favorably against limited or full information estimation methods in regards to robustness against specification error. Furthermore, "simultaneous" relationships are a result of the model specification. In particular, aggregation over time enforces simultaneous specification since the model abstracts from the tantomment or process of adjustment to which any economic system is subject. Wold has argued that simultaneous economic models are really misspecified recursive systems. Furthermore, the OLS technique has been shown in Monte Carlo studies to maintain the Gauss-Markov property of minimum variance. As a technique it is computationally the most simple and inexpensive. In a system as large as the MSU Agriculture Model any variant of the limited or full information techniques would place an onerous burden upon degrees of freedom. Various researchers, Mosbaek and Wold, (1979) Smith, (1973) and Intrilligator (1978) have found that OLS tends to improve relative to the limited information estimate as the model size increases. Finally the more recursive the model the stronger the argument for use of OLS methods.

The MSU Agriculture Model is estimated as a set of linear relations. Only a few relationships are non linear with respect to the variables but are estimated as linear models with respect to the parameters. Examples of these equations are log-log, semi-log, and polynomial lag models. These variable transformations will be noted in the discussion of those equations.

Serial correlation was not a pervasive problem, however its presence was common enough. It was consistently tested for and in estimated equations where it was significant, alternative procedures, either the Cochrane-Orcutt iterative method or Hildreth-Lu maximum likelihood estimations were used to correct for serial correlation.

Solution Algorithm

The calculation procedure for the computer solution employs the interative Gauss-Siedel method. This technique is appropriate for this model for several reasons. Since the model is structured to reflect a recursive economic system, the interactive equation-by-equation solution search is a useful approximation to the real world solution process. An iterative method allows for more flexibility than a matrix inversion as constraints can be more easily and explicitly introduced and become embodied into the solution space.

The calculation procedure for the computer solution employs the Gauss-Seidel method, Pennington (1970). This procedure follows an iterative search for a solution vector, Y. After each iteration the quantity

$$D = \sum_{i=1}^{n} y_i^{new} - y_i^{old}$$

is calculated and compared against a given number C, which is the critical value for convergence. If D is less than C, the solution is accepted and printed.

It is important to note that this procedure does not always guarantee convergence. There is also no certainty attached to the number of iterations required for solution. Each iteration involves n^2 multiplications (where n equals the number of erdogenous variables in the model). In terms of efficiency, if more than (1/3)n iterations are required for convergence, other solution methods are likely to be more efficient. For a system of two equations the convergence problem reduces to the way in which equations are ordered.

For a system of equations as large as the MSU Agriculture Model, the convergence and equation ordering is complex. A rearrangement of equations may or may not generate a more efficient convergence. However, it is possible to improve the likelihood of converging upon a solution if the solution vector is ordered such that each element of the diagonal of the coefficient matrix is the largest in absolute value within each variable's respective equation. Convergence is guaranteed if the absolute value of the coefficient is greater than the sum of the absolute values of the remaining coefficients.

In a three equation model these conditions can be demonstrated in terms of the coefficient matrix.

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

The likelihood of convergence is increased if: the absolute values of a_{ii} are greater than the absolute values of any a_{ij} in the same equation

$$|a_{11}| > |a_{12}|, \quad |a_{13}|$$
$$|a_{22}| > |a_{21}|, \quad |a_{23}|$$
$$|a_{33}| > |a_{31}|, \quad |a_{32}|$$

and convergence is assured if for every row,

$$|a_{ii}| > \sum_{j=1}^{n} |a_{ij}|, \quad i \neq j.$$

The computer package which is presently used for solution was developed in the USDA and is documented. The solution package is called a General Analytical Simulation Solution Program (GASSP). This program consists of two basic components. The solution component SOLVIT which uses the Gauss-Siedel method discussed above. The other component includes two subroutines, XMODL and COEF. XMODL contains the model equations to be solved. COEF is a supporting subroutine to provide flexibility and efficiency to the XMODL-SOLVIT interface. Endogenous variables are denoted by a Y script while exogenous variables are represented by a Z script.

The solution process begins with an initialization array. $YY_{i,0}$ = Actual values if they exist and the previous year's values if not. These values are evaluated in the equations in YMODL to generate an interim solution for the first iteration equal to $YY^{T}_{i,1}$. This solution array returns to SOLVIT to generate the final solution for the first iteration $YY_{i,1} = .25 * YY^{T}_{i,1} + .75 * YY_{i,0}$. If $D = \sum_{i=1}^{n} YY_{i,t} - YY_{i,t-1}$ is equal to or less than the critical convergence value, then the simulation stops. If not, the values are returned, passed through XMODL repeatedly until the convergence criterion is met.

CHAPTER III

Model Structure

Overview

The objective of this chapter is to describe the model structure of United States livestock supply and demand, crop supply and domestic feed grain and wheat demand. The model is an integrated system of commodity models (Figure 1). The crop sector includes wheat, corn, sorghum, barley, oats, soybeans and cotton. The U.S. livestock sector includes beef, dairy, pork and poultry. In total these commodities account for approximately 80% of the U.S. farm income. The model generates estimates for all the endogenous variables on an annual basis. The livestock sector is based on a calender year. All crops are based on their respective crop marketing year. In very general terms, the model is dynamic in as much as it is designed to simulate the modeled activities over time, recursively with the solution in period t being an input into the solution of period t + 1. The dynamics of this model however are rather naive. Dynamic economic concepts such as risk and uncertainty, investment and disinvestment, are not treated in an extensive or explicit way. Certain specifications attempt to proxy some of these aspects. The hypothesized relationships of the role of price and profit expectations and partial adjustment, due to information, structural and technical lags contribute to the dynamic specification in the model.

The conceptual derivation of the supply and demand equations are based upon the aggregation of all firms' (consumers') first order con-

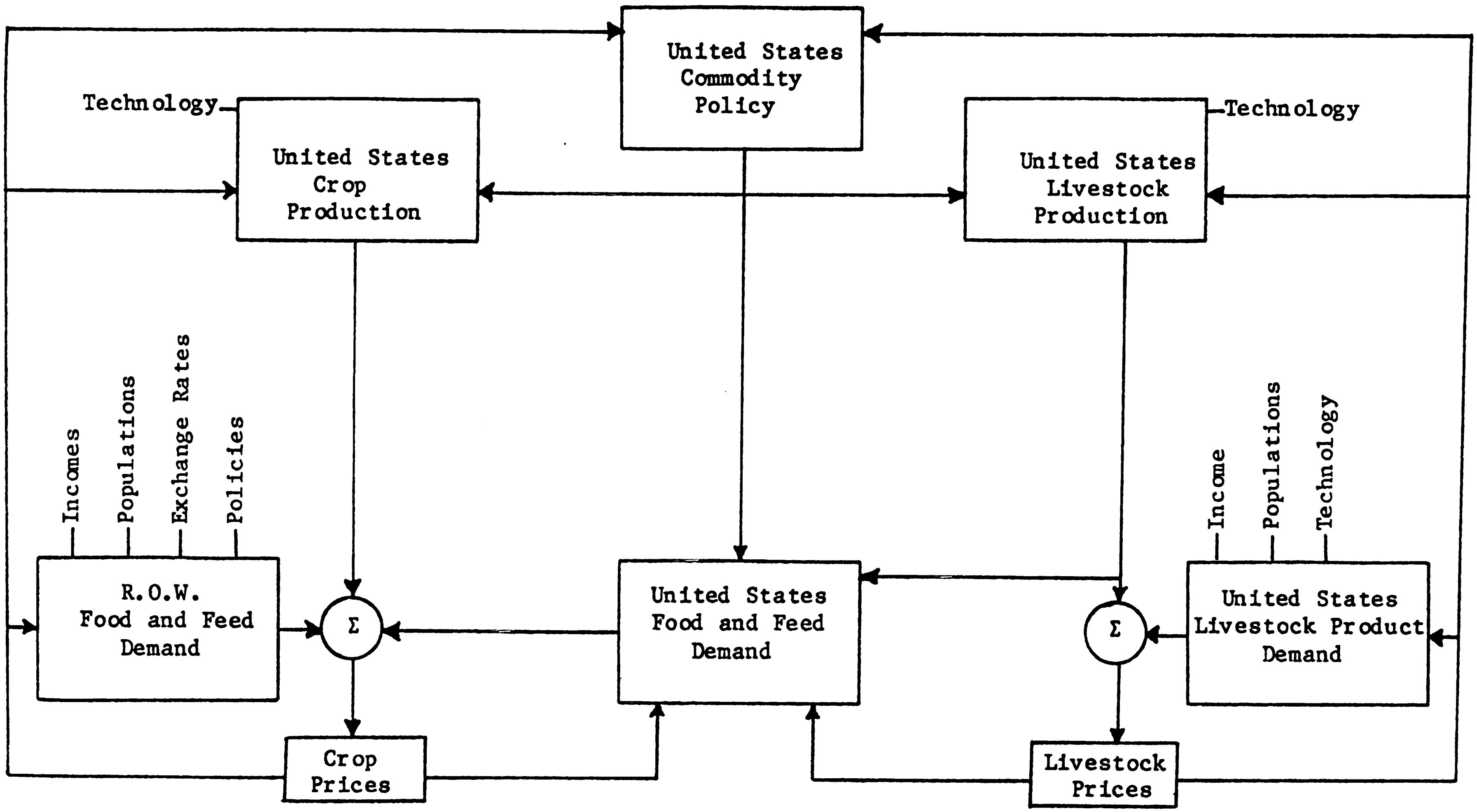

Figure 1. Generalized Diagram of United States Grains-Oilseeds-Livestock Model

ditions for each individual firm's (consumer's) profit (utility) maximization.

No easy rule exists for the determination of the endogenous/exogenous classification of model variables. The issues of causality, model size, and management capabilities were important in this aspect of the model development. Most variables are either endogenous or exogenous always, however some components while treated as exogenous historically become endogenous over the forecast period. Table 1 categorizes the variables regarding the endogenous/exogenous dichotomy.

Presentation of Empirical Results

The equations are reported with the following information:

OLS - Ordinary Least Squares.

CORC - Cochrane Orcutt iterative method for serial disturbance.

HILU - Hildreth-Lu maximum likelihood scan for serial disturbance.

Both *a priori* and *ex post* judgement was made about the relevant estimable period for each individual equation.

Standard error of the parameter estimate is presented parenthetically below the respective estimate.

Rho - The value of the coefficient of serial correlation and its standard error in parenthesis.

R^2 - Coefficient of determination; where alternative equations are compared, the $\bar{R}^2$ which corrects for degrees of freedom is given.

TPE - Turning point errors will be given in terms of number of errors in turn as a ratio to all turns.

$\frac{SE}{M}$ - Standard Error of the regression will be given as a percent of the mean of the dependent variable over the period of estimation.

Table 1. Model Variable Classification

Endogenous Components	Exogenous Components
Wheat Supply, Disappearance and Prices	Population
Corn Supply and Prices	Income
Sorghum Supply and Prices	Weather
Barley Supply and Prices	Land Availability
Oat Supply and Prices	Exchange Rates
Feedgrain Disappearance	General Price Indexes
Soybean supply and Prices	Transportation Rates
Soymeal and Soyoil Disappearance and Prices	Fertilizer Prices
Cotton Supply, Disappearance and Prices	
Beef Inventory, Slaughter, Consumption and Prices	
Pork Inventory, Slaughter, Consumption and Prices	
Dairy Inventory, Production, Consumption and Prices	
Broiler Supply, Consumption and Prices	
Turkey Supply, Consumption and Prices	
Egg Supply, Consumption and Prices	

Exogenous in Estimation/Endogenous over Forecast
U.S. Farm Commodity Programs

D.W.- Durbin Watson statistic is given if the equation was not estimated with a correction for serial correlation or as a function of a lagged dependent variable. In the latter case the Durbin's h statistic is presented.

Crop Supply

U.S. production of wheat, feed grains and soybeans was estimated for the model. Feed grains were disaggregated into corn, sorghum, barley and oats. Production estimates are generated by the number of acres harvested multiplied by the yield per acre for each crop. Acres harvested are estimated as a simple function of estimated planted acreage. The behavioral relationships for crop supply are specified in the acres planted equation.

The crop acreage supply relationships specified for this model were developed out of previous theoretical and empirical studies (Nerlove, Houck, et al., McKeon). The empirical estimates of the acres planted equations provide information on a set of variables which are hypothesized in explaining agricultural supply. The objective of this discussion is to present and evaluate these estimated models in terms of their correspondence to results of previous studies and our understanding of their structural parameters.

The approach to analysis of crop supply functions by concentrating upon the independent estimation of supply relationships for the factors of production has been developed in the seminal articles by D. G. Johnson (1950) and M. Nerlove (1958) in the 1950's. This theoretical framework is based upon the neoclassical economic theory which assumes that firms maximize profits and the demand for the factors of production are determined by conditions of marginal equilibrium, where marginal revenue product equals marginal factor cost. In a break from the earlier attempts to explain supply in response to the previous year's price, Nerlove's studies emphasized the notion that "farmers react not to last year's price but rather to the price they expect, and this expected price depends only to a limited extent on what last year's price was." From this hypothesis came the development of models to explain the price expectation of farmers. The simultaneous development of econometric distributed lag models provided relatively sophisticated empirical methods for identifying and testing the specification of the expectations model, (Griliches, Askari and Cummings). In the 1960's empirical investigations such as the Interstate Managerial Survey (Johnson, et al.) generally supported the expectations hypothesis but advanced that forward-looking information available to farmers, not reflected in past prices, was important in the formulation of farmers' expectations.

In the later 60's and early 70's, several studies recognized the importance of the "forward price" impacts of government programs on crop acreage supply by farmers. The concept of forward prices developed by D. G. Johnson (1947) became embodied in government programs from the fifties to the present with the objective to influence crop acreage. The identification of the impact of forward price levels as reflected in loan rates and target prices is useful both in terms of how it indirectly conditions the response to past market prices and price uncertainty as well as identifies the direct impact on crop acreage, (Houck, et al). Just (1974) has extended the price expectations-government intervention supply model to explicity include the impact of price uncertainty on supply behavior.

The general model specification, reflecting the above discussion, is given by the following equation.

$$AP_t = f(\frac{P_{t-1}}{CI}, PV_1, PV_2, R_t, AP_{t-1})$$

where AP_t = acres planted in period t

P_{t-1} = vector of lagged market prices

CI = Index of costs, CPI was used in all deflations

PV_1 = vector of effective support prices, deflated

PV_2 = vector of effective diversion payments, deflated

R_t = $(P_{t-1} - (\sum_{i=2}^{4} P_{t-i}/3))^2 / (\sum_{i=2}^{4} P_{t-i}/3)$, a vector of market price variances

AP_{t-1} = acres planted, lagged one year.

The previous empirical studies by Houck, et al and McKeon have analyzed crop acreage supply functions in a comprehensive and consistent way for the same crops considered in this model. The following presentation of equations reflects an updating of McKeon's equations and the extension of the policy variable concepts to encompass the changing policy framework as legislated in the 1973 and 1977 Food and Agriculture Acts. This supply framework provides a straightforward basis for simulations assuming alternative government policy strategies and objectives.

There are several policy instruments important to supply control which are all incorporated into the model explicitly. Furthermore, over the forecast period the farm policy process is hypothesized as endogenous to the supply and demand framework. The specification of the policy variables and a discussion of the endogeneity of the policy process are presented in Chapter IV.

A block diagram on the following page, Figure 2, identifies the generalized specification estimated for each crop. The two composite policy variables are called the effective support rate and the effective diversion rate. It is sufficient at this stage to define the effective support rate as the government policy incentive to produce the "desired" level of production. The effective diversion payment represents the government policy disincentive to supply land for production of the crop.

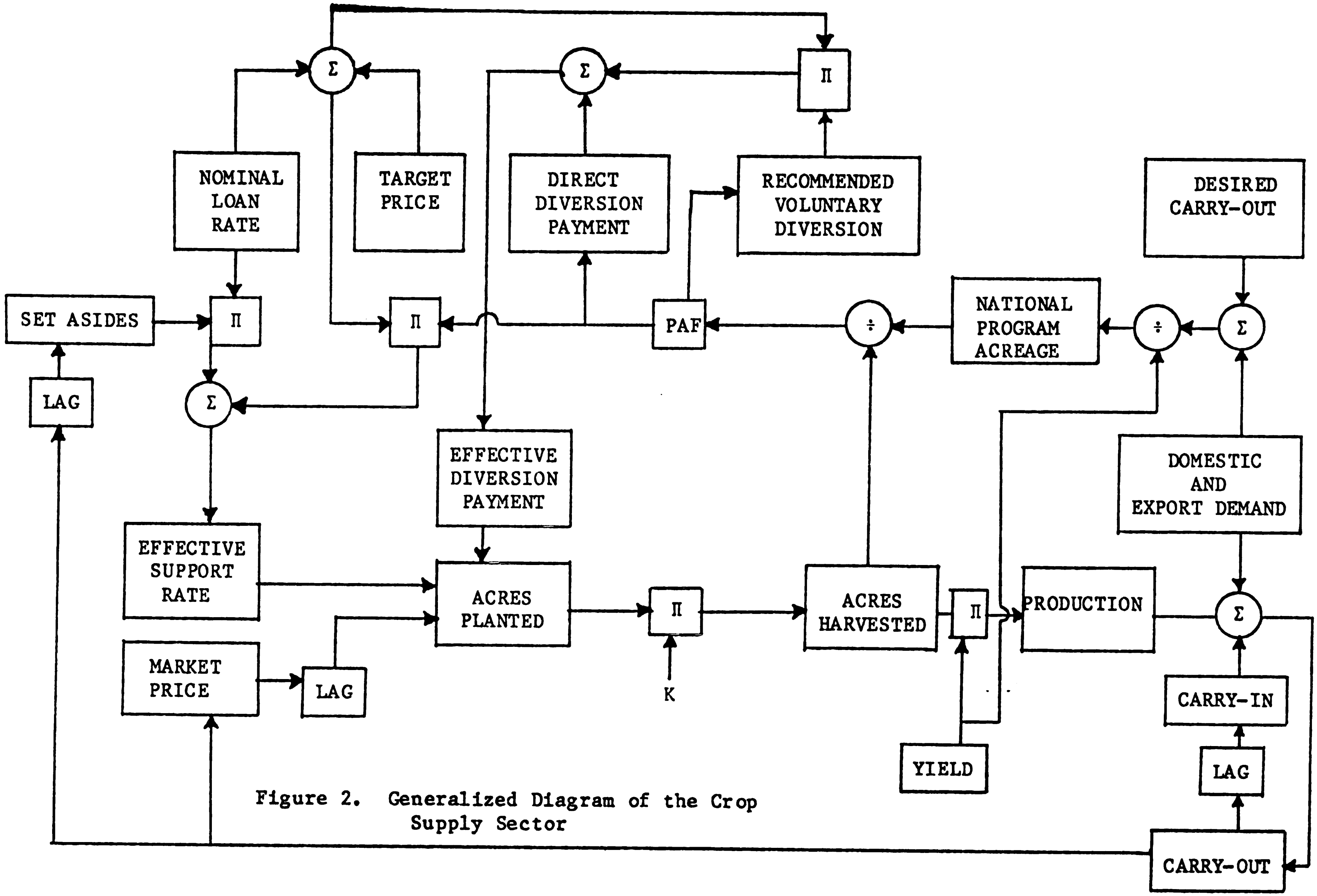

Figure 2. Generalized Diagram of the Crop Supply Sector

Wheat

Wheat acres planted are associated with lagged wheat and corn prices, wheat effective support rate and the wheat effective diversion payment. Considerable differences in wheat cultivation exist in the U.S. However, these important regional considerations and differences in wheat type were not disaggregated. The specification of corn as a substitute crop is not appropriate for much of the wheat belt. However, in regions that produce soft red winter varieties, corn is a substitute.

The estimated equation has expected signs for all variables. The coefficient for corn price is not significantly different from zero. The relationship appears reasonable both in terms of magnitude and direction. An equation excluding corn price was estimated with no significant difference in either explanatory power or the relationships estimated for other explanatory variables. The equation for acres harvested is estimated as a direct proportion of acres planted.

Table 2. Wheat Acreage Supply Equations

Dependent Variable	Intercept	WP_{t-1}	CP_{t-1}	PV_1WT	PV_2WT	TL
Acres Planted =	-359519 (81381)	10936.1 (4848)	-4195.5 (9551)	16002.2 (6445)	-21017.7 (12451)	91117.7 (19091)

Dependent Variable: Acres planted to wheat, thous. acres.

Independent Variables:

WP_{t-1}: deflated wheat price received by farmers, \$/bu. lagged one year

CP_{t-1}: deflated corn price received by farmers, \$/bu. lagged one year

PV_1WT: deflated effective support rate for wheat \$/bu.

PV_2WT: deflated effective diversion payment, \$/bu.

TL: trend, log (i), i=61,...,78

Estimation Period: 1961-1978

Estimator: OLS

R^2 = .858
D.W. = 2.07
S.E./Mean = 4263/60628 = 7%
T.P.E. = 5/17 = 29%

Dependent Variable	Independent Variables: Acres Planted
Acres Harvested =	.88 (.005)

Dependent Variable: Acres Harvested of wheat, thous. acres.

Independent Variable: Acres Planted to wheat, thous. acres.

Estimation Period: 1960-1978

Estimator: OLS

R^2 = .977
D.W. = 1.86
S.E./Mean = 1383/54110 = .03
T.P.E. = 3/18 = 17%

Corn

The supply model for corn is based upon the relationship between corn plantings and lagged corn, soybean and wheat prices and government feed grain programs (Table 3). The estimates for this equation reflect the importance of the government support rate and the corn/soybeans substitution. All coefficients are of the expected direction and reflect in a reasonable way the relative importance of the various factors.

As with wheat, a simple proportion of the planted acreage was estimated to generate this variable. The other major use of planted corn is silage. An estimated relationship for acreage harvested for silage includes the planted acreages and lagged corn price. The positive relationship to price reflects that the percent of acreage harvested for silage increases in years of higher expected prices perhaps due to overadjustment. Silage production is an alternative to incurring lower cash grain prices.

Table 3. Corn Acreage Supply Equations

Dependent Variable	Independent Variables						
	Intercept	CP_{t-1}	SP_{t-1}	WP_{t-1}	PV_1CT	PV_2WT	TL
Acres Planted =	-107515	12882.8	-3631.3	-3255.4	27630.2	-20831.4	37596.1
	(102737)	(7117.5)	(1618)	(3268)	(8530)	(25519)	(22296)

Dependent Variable: Acreage planted to corn, thous. acres.

Independent Variables:

CP_{t-1}: deflated corn price received by farmers, $/bu. lagged one year

SP_{t-1}: deflated soybean price received by farmers, $/bu. lagged one year

WP_{t-1}: deflated wheat price received by farmers, $/bu. lagged one year

PV_1CT: deflated effective support rate for corn $/bu.

PV_2CT: deflated effective diversion payment, $/bu.

TL: trend, log (i), i = 66, ... 78

Estimation Period: 1966-1978

Estimator: OLS

R^2 = .972

D.W. = 1.72

S.E./Mean = 1691/73192 = 2%

T.P.E. = 2/8 = 25%

Table 3 (cont'd)

Dependent Variable	Independent Variables
	Acres Planted
Acres Harvested for Grain =	.856
	(.002)

Dependent Variable: Acres harvested for grain, thous. acres.

Independent Variable: Acres planted to corn, thous. acres

Estimation Period: 1961-1978

Estimator: OLS

R^2 = .983
D.W. = 1.85
S.E./Mean = 751/60990 = 1%
T.P.E. = 0/12 = 0%

Dependent Variable	Independent Variables	
	Acres Planted	CP_{t-1}
Acres Harvested for Silage =	.097	1353.6
	(.01)	(564)

Dependent Variable: Acres harvested for silage, thous. acres.

Independent Variable: Acres planted to corn, thous. acres

Estimation Period: 1960-1978

Estimator: OLS

R^2 = .774
D.W. = 2.34
S.E./Mean = 538/8691 = 6%
T.P.E. = 5/12 = 29%

Sorghum

Sorghum is the second most important feed grain in the United States, although sorghum acreage is generally less than one-fourth of corn acreage. It can withstand rainfall variation better than corn and tends to be planted in areas where moisture variability is sometimes critical. This aspect is reflected in both the variability in its yields and acreage. In the southern states cotton has traditionally been an alternative crop. Government policy for sorghum has always been closely adjusted with programs for corn. Thus the effective support rate for corn is a reasonable proxy for the sorghum program as well.

This crop was without question the most difficult supply model to estimate. Dummy variables were used in years where the model was unable to explain additional plantings in the magnitude of 10 percent. This additional planting to sorghum is possible since short season varieties are available which can be planted to replace an unsuccessful seeding of corn or cotton. Most of the estimated coefficients are not extremely significant statistically, although all have expected signs.

The harvested acreage for grain is associated with acreage planted and a trend (log of time) over time for an increasing percent of sorghum to be harvested as grain rather than silage or forage. The silage harvested acreage is estimated as a simple proportion of total acreage planted. To the extent that grain varieties have replaced silage varieties in the total acres planted some trend variable should be identified in this relationship. However the major substitution toward grain harvested acres has been away from forage acres harvested which are not included in the model.

Table 4. Sorghum Acreage Supply Equations

Dependent Variable	Independent Variables					
	Intercept	SP_{t-1}	CP_{t-1}	PV_1CT	PV_2SHT	DV6035
Acres Planted =	20300.7	870.4	-239.6	3052.4	-2181.2	1491.1
	(4570)	(1021)	(619)	(3855)	(4256)	(636)

Dependent Variable: Acreage planted to sorghum, thous. acres.

Independent Variables:

SP_{t-1}: deflated sorghum price received by farmers, \$/bu. lagged one year

CP_{t-1}: deflated cotton price received by farmers, \$/bu. lagged one year

PV_1CT: deflated effective support rate for corn \$/bu.

PV_2SHT: deflated effective diversion payment for sorghum, \$/bu.

DV6035: Dummy variable = 1, 1960, 1963, 1965; = 0, otherwise

Estimation Period: 1960-1978

Estimator: OLS

R2 = .737

D.W. = 2.22

S.E./Mean = 870/17342 = 5%

T.P.E. = 5/17 29%

Table 4 (cont'd)

Dependent Variable	Independent Variables		
	Intercept	Acres Planted	TL
Acres Harvested for Grain =	-21351 (3536)	.749 (.06)	52079 (801)

Dependent Variable: Acres harvested for grain, thous. acres

Independent Variable: Acres planted to sorghum, thous. acres
TL: trend, log (i), i = 65, ... 78.

Estimation Period: 1965-1978

Estimator: CORC
R^2 = .949
Rho = .69
S.E./Mean = 255/14254 = 2%
T.P.E. = 1/12 = 8%

Dependent Variable	Independent Variables
	Acres Planted
Acres Harvested for Silage =	.043 (.004)

Dependent Variable: Acres harvested for silage, thous. acres

Independent Variable: Acres planted to sorghum, thous. acres

Estimation Period: 1960-1978

Estimator: CORC
R^2 = .888
Rho = .83
S.E./Mean = 65/940 = 7%
T.P.E. = 5/16 = 31%

Barley

The barley crop is influenced by the feed grain, wheat and beer markets. It is produced in various regions but the most important, the north central states is an area where wheat is the predominant alternative. Yet it competes as a feed grain with corn, sorghum and oats. The supply equation attempts to reflect these various factors.

The estimates are all significant and of the expected sign. The importance of the wheat sector is particularly recognized in this model. The wheat diversion payment is based upon observations when cross-compliance in government program participation was not an issue.

A significant increase in the percent of barley acreage harvested over the estimation period suggested that a proxy for this trend be included in the acres harvested equation. Possible reasons for this increasing harvested proportion include declining use for cover cropping, grazing and forage.

Table 5. Barley Acreage Supply Equations

Dependent Variable	Independent Variables					
	Intercept	WP_{t-1}	$\frac{PV_1BT}{PV_1CT}$	PV_2BT	PV_2WT	APW_{t-1}
Acres Planted =	6531.1 (785)	9102. (1350)	775.4 (489)	-3638.1 (1569)	3802.1 (1361)	-.057 (.008)

Dependent Variable: Acres planted to barley

Independent Variables:

WP_{t1}: deflated wheat price rec. by barley, \$/bu. lagged one year

PV_1BT: deflated effective support rate for barley, \$/bu.

PV_1CT: deflated effective support rate for corn, \$/bu.

PV_2BT: deflated effective diversion payment for barley, \$/bu.

PV_2WT: deflated effective diversion payment for wheat, \$/bu.

APW_{t-1}: acres planted to wheat, lagged one year

Estimation Period: 1965-1978

Estimator: OLS

R^2 = .936

D.W. = 2.72

S.E./Mean = 238/10219 = 2%

T.P.E. = 1/13 = 8%

Table 5 (cont'd)

Dependent Variable	Independent Variables	
	Acres Planted	TL
Acres Harvested =	.7	518.2
	(.03)	(74)

Dependent Variable: Acres harvested for barley, thous. acres
Independent Variable: Acres planted to barley, thous. acres
TL: trend, log (i), i = 60, ..., 8)
Estimation Period: 1960-1978
Estimator: OLS

$R^2 = .969$
D.W. = 1.58
S.E./Mean = 226/9876 = 2%
T.P.E. = 0/17 = 0%

Oats

Acreage planted to oats has in general declined rapidly over the recent period of years. The livestock species which tends to be more intensive users of oats in their rations, e.g. horses and sheep, have declined tremendously in numbers. To a large extent this land has been bid away into more profitable corn and soybeans. This has been somewhat reinforced by government feed grain programs.

A seemingly unexplainable reversal of declining acreage occurred in 1968 which essentially shifted the time-series. All of the expanded acreage was located in the north central region of the United States, including Minnesota, North and South Dakotas, Nebraska and Montana. This may reflect aspects of the barley market which supported a temporary shift toward oats. All estimated coefficients are significant and of the expected relationship with the dependent variable.

Over time oats have tended to be planted for use as a short crop for purposes other than grain production such as crop cover, green manure, etc. Thus the proportion of the acres harvested has declined over time. This is tested in the estimated equation by the variable TL.

Table 6. Oats Acreage Supply Equations

Dependent Variable	Independent Variables					
	Intercept	OP_{t-1}	PV_1OT	PV_1CT	APO_{t-1}	DV68ON
Acres Planted	-5869.1 (1547)	4979.5 (828)	12944.2 (1128)	-5431.6 (735)	.88 (0.37)	2706.4 (329)

Dependent Variable: Acres planted to oats, thous. acres

Independent Variables:

OP_{t-1}: deflated oat price received by farmers, $/bu., lagged one year

PV_1OT: deflated effective support rate for oats, $/bu.

PV_1CT: deflated effective support rate for corn, $/bu.

APO_{t-1}: acres planted to oats, lagged one year

DV68ON: dummy variable = 1, 1968-1978; = 0, otherwise

Estimation Period: 1962-1978

Estimator: HILU

R^2 = .989
Rho = .73
(.17)
S.E./Mean = 465/2117 = 2%
T.P.E. = 1/15 = 7%

Table 6 (cont'd)

Dependent Variable	Independent Variables	
	Acres Planted	TL
Acres Harvested	.81 (.04)	306 (203)

Dependent Variable: Acres harvested of oats, thous. acres.

Independent Variables:
Acres planted to oats, thous. acres.
TL = trend, log (i), i = 60, ... 78.

Estimation Period: 1960-1978
Estimator: OLS
R^2 = .974
D.W. = 1.99
S.E./Mean = 561/16220 = 3%
T.P.E. = 3/16 = 19%

Soybeans

Acreage planted to soybeans has increased dramatically over the forecast period. This has been accomplished as a competitive alternative in the corn belt. It has become the major protein source in animal feeds and thus its growth in supply has been easily accommodated by growth in livestock feeding at home and abroad.

The supply relationship recognizes the importance of the corn market and to a lesser extent wheat which is only significant in regions which produce the soft eastern wheat varieties.

Nearly all soybeans planted are harvested. However given that the total area has increased over time, it is reasonable to expect that for various reasons such as greater environmental variability that the proportion of crop harvested will decline. This is reflected by the trend proxy.

Table 7.

Table 7. Soybean Acreage Supply Equations

Dependent Variable	Independent Variables						
	Intercept	PSB_{t-1}	$\frac{SBP_{t-1}}{CP_{t-1}}$	WP_{t-1}	PV_1SBT	PV_1ICT	PV_2CT
Acres Planted =	4516.9 (11804.2)	.71 (.11)	9827.0 (2115)	-1797.2 (1517)	1833.6 (2656)	-10600 (8319)	-36493 (22647)

Dependent Variable: Acres planted to soybeans, thous. acres.

Independent Variables:

$APSB_{t-1}$: acreage planted to soybeans, thous. acres., lagged 1 year.

SBP_{t-1}: deflated soybean price rec. by farmer, \$/bu., lagged 1 year.

CP_{t-1}: deflated corn price rec. by farmer, \$/bu., lagged 1 year.

WP_{t-1}: deflated wheat price rec. by farmer, \$/bu., lagged 1 year.

PV_1SBT: deflated effective support rate for SB/Sbu.

PV_1CT: deflated effective support rate for corn/\$/bu.

PV_2CT: deflated diversion payment for corn/\$bu.

Estimation Period: 1960-1978
Estimator: OLS

R^2 = .978
D.W. = 2.89
S.E./Mean = 1998/43666 = 5%
T.P.E. = 4/17 = 24%

Table 7 (cont'd)

Dependent Variable	Independent Variables	
	Acres Planted	TL
Acres Harvested =	1.0	-188.9
	(.0025)	(27)

Dependent Variable: Acres harvested of soybeans, thous. acres

Independent Variables:
Acres planted to soybeans, thous. acres
TL: trend, log (i), i = 60, ..., 78

Estimation Period: 1960-1978
Estimator: OLS
R^2 = .999
D.W. = 2.17
S.E./Mean = 130/43631 = 1%
T.P.E. = 0/16 = 0%

Analysis of the Supply Relationships: The Case of Corn Acreage

In the following discussion a detailed review of the corn model is presented. Table 8 summarizes seven alternative specifications and defines the variables. A set of alternative corn models were estimated and are presented in Table 9.

Acreage planted to corn is significantly influenced by market prices, government commodity programs and price uncertainty. The partial adjustment model cannot be rejected in explaining year-to-year changes in planting. Full adjustment within one period is impeded by technological and psychological inertia. A good example of this is the role which crop rotation likely plays. Most corn rotation schemes involve at least a two year cycle. Farmers are aware that there is a longer run return to this practice and the partial adjustment specification reflects the predetermining force.

The comparison of the significant difference in the t statistic on trend in models 5 and 6 as well as a null F test between 6 and 7 suggests that a time trend in a full adjustment model alternatively is associated with the partial adjustment effect. Inasmuch as the lagged dependent variable is not necessarily expected to be highly correlated with trend into the forecast, there is considerable preference to use a structural variable.

The implications of a partial adjustment specification are significant in terms of the measured elasticities for the other explanatory variables.

The Impact of Commodity Programs

Government program variables displayed considerable explanatory power in these estimations. The effective corn support rate, PV_1CT has

Table 8. Alternative Model Specifications for Corn Acreage Supply

Model	Substitute Crops	Price Variability	Acreage Adjustment Lagged Dependent
1	Soybeans, Wheat	None	Total
2	Soybeans	None	Total
3	Soybeans	Corn Price	Total
4	Soybeans	Corn/Soybeans	Total
5	Soybeans, Wheat	Corn/Soybeans	Total
6	Soybeans, Wheat	Corn/Soybeans	Partial
7	(same as Model 6 but without time trend)		

Variable Definitions

TL = trend, log (i) = 66, ... 78

PV_1CT = deflated effective support rate for corn, \$/bu.

PV_2CT = deflated effective diversion payment for corn, \$/bu.

CP_{t-1} = deflated corn price received by farmers, \$/bu. lagged one year.

WP_{t-1} = deflated wheat price received by farmers, \$/bu., lagged one year.

SBP_{t-1} = deflated soybean price received by farmers \$/bu., lagged one year.

CRISK = $((CP_{t-1} - (\sum_{i=2}^{4} CP_{t-i})/3)^2)/((\sum_{i=2}^{4} CP_{t-i})/3)$, moving market price variance.

CBRISK = CRISK/SBRISK, where SBRISK is defined for soybean prices similar to CRISK.

APC_{t-1} = lagged acres planted to corn, one year.

Table 9. Alternative Corn

Table 9. Alternative Corn Acreage Supply Equations

MODEL	INTERCEPT	TL	PV_1CT	PV_2CT	CP_{t-1}	WP_{t-1}	SBP_{t-1}	CRISK	CBRISK	APC_{t-1}	$\bar{R}^2$	D.W.	S.E./M	T.P.E.
1 B	-107515	37596	27630	-20831	12882	-3255	-3631				.971	1.72	.023	3/12
SE	(102737)	(22296)	(8530)	(25519)	(7117)	(3269)	(1619)							
E			.305	-.036	.228	-.071	-.153							
2 B	-121609	4116	27895	-17765	7787		-3724				.967	2.02	.023	2/12
SE	(101698)	(22001)	(8521)	(25318)	(4944)		(1615)							
E			.308	-.030	.138		-.156							
3 B	-170797	50549	28814	- 6943	10766		-2417	-9502			.983	2.10	.018	1/12
SE	(80051)	(17202)	(6505)	(19792)	(3958)		(1340)	(3863)						
E			.318	-.012	.190		-.102	-.015						
4 B	-124948	42337	27303	-19047	6382		-3307		-558		.980	2.27	.019	2/12
SE	(84878)	(18369)	(7117)	(21136)	(4185)		(1363)		(277)					
E			.302	-.032	.113		-.139		-.010					
5 B	-115604	39969	27185	-20902	9778	-2090	-3285		-508		.982	2.16	.020	2/12
SE	(89529)	(19542)	(7428)	(22208)	(6455)	(2925)	(1423)		(297)					
E			.300	-.035	.173	-.057	-.138		-.009					
6 B	8101	8552	20235	-36083	12414	-4511	-3359		-608	.264	.993	-.699*	.014	1/12
SE	(79249)	(18388)	(5853)	(16567)	(4606)	(2249)	(989)		(210)	(.10)				
E-SR			.224	-.060	.219	-.122	-.141		-.011					
-LR			.304	-.081	.298	-.166	-.191		-.015					
7 B	44723		18758	-41963	12258	-4932	-3236		-616	.297	.993	-.699*	.013	2/12
SE	(8173)		(4515)	(9832)	(4219)	(1889)	(816)		(193)	(.07)				
E-SR			.207	-.070	.217	-110	-.136		-.011					
-LR			.294	-.100	.309	-.156	-.193		-.016					

*Durbin's h Statistic

a statistic which is generally above the 1 percent level of significance across all specifications.

The short run (SR) elasticity implied by the partial adjustment model is +.21. The long run (LR) elasticity is +.29. This is approximately equal to the elasticity estimated in the full adjustment models. To the extent that the partial adjustment model is in general a superior explanation, the lower SR responsiveness to support rates has operational siginificance for government program management. Houck et al report considerably lower elasticities, in the range of .12 - .13. McKeon's estimate is +.139. However comparisons with the Houck et al and McKeon estimates need to be qualified. Neither of the models which they report include a lagged dependent variable. Houck et al do include a time trend which as argued above proxies the lagged dependent variable over the historical period. It is however in a form which does not facilitate estimating a different SR-LR elasticity. Another important difference is the period of estimation. The Houck models are estimated from 1949-1969 and 1950-1974 data. The observations earlier than 1965 were rejected in this study for two reasons. As the Houck study has demonstrated, the substitution relationship between corn and sorghum acreage through the 1950's was structurally different than in the period thereafter. Second, the Food and Agricultural Act of 1965 altered the feed grain program method of direct support payments in a manner which made the distinction between PV_1C and the diversion payment PV_2C ambiguous.

The implication of the significant difference in elasticities in this study compared to earlier estimates suggests that the relationship between government programs and acreage supply has become more elastic in the 1970's. In fact the estimated elasticity for the period 1957-1974 for PV_1CT, based on the specification in 7) is estimated at +.08, at the mean. One reason for the change which may be suggested is that in a period of volatile market prices, which characterized the 1970's, the certainty associated with the support rate generated an increased reliance or responsiveness to this forward price. The role of the support rates in moderating price uncertainty however is far from complete as suggested by the importance of the price variance variable. Another possible explanation which relates more to the political process is that support rates have responded to validate market price increases. The correlation between the effective support rate and the real price of corn lagged one year is +.4. This suggests that the price expectations of politicians also are partially influenced by the past year's price. It is politically wellmeaning to raise support rates when high prices are expected because it doesn't cost anything in the short run. The trap is of course that political prices tend to be downwardly rigid. However, imposition of quantitative controls, as embodied in the set-aside programs, enables the higher nominal support prices to be effectively lowered.

This has likely contributed to the ability to avoid what otherwise could have been tremendous surpluses in the late 70's. A relevant recent study by Gallagher (1978) on the United States corn acreage response presents a method for examining the influence of the price supports under variable market conditions. He estimates a parameter which reflects an inverse weighting on the relative importance of market price and support rates. His estimates of support rate elasticities range between +.13 to +.02 over the period 1954 to 1977. This method is based upon the conceptual formulation that support rates truncate the left tail of the price probability density function in a more significant way the closer the market is to the support rate. Thus it should play a relatively more important allocative role. While this has intuitive appeal, it ignores several important aspects which makes the analytical framework restrictive.

First and most important is that the level of the effective support rate is not exogenous to market conditions. In fact as suggested above, there is a tendency for the effective support rate to move in the direction of the market forces. Weak market conditions imply the imposition of set asides which reduces the effective support rate. Similarly strong market conditions afford political philanthrophy, i.e., raises the effective support rate. Further, competitive forces of agriculture raise costs of production in line with the rising marginal returns. Cost increases imply target price increases which in turn raise the effective support rate. Thus the argument by Gallagher that "other methods assume that the response to support price is constant, regardless of market conditions" does not recognize the dynamic relationships of support rates to market conditions. Thus, the changing levels of support rates, inherently reflecting market conditions, generate changing responses. And this response changes in a way which is contradictory to the direction Gallagher imposes upon the model.

The following table compares short run price support and market price elasticities at "weak" and "strong" market conditions.

Table 10. Market and Support Price Elasticities for Corn by Market Condition

		Gallagher		This Study	
Market Condition	Period	Price Support	Market Price	Price Support	Market Price
Weak	1969-72	.13	.06	.19	.19
Strong	1973-76	.06	.18	.21	.27

The elasticities estimated in this study are significantly higher. Responsiveness of farmers to effective support rates does not appear to be truncated in a direction as presented by Gallagher. In light of this contradictory evidence the difference in results must be attributed to either a) differences in data, b) difference in estimation period, or c) differences in specification and functional form. The difference in the estimation period has been noted and is believed to contribute to the difference in magnitudes of the elasticities. Data series for each model have been compared and are consistent. Thus the difference in the estimated results for the strong:weak market hypothesis are likely related to difference in specification and functional form.

The objections to the conceptual framework by Gallagher identified above include: 1) the failure to recognize that price supports are dynamically related to market conditions, 2) that last year's price should not be equated with the price expectation to be truncated, and 3) the distinction between strong and weak price <u>levels</u> and price <u>movement</u> is not made.

The diversion payment variable is not significantly different from zero except in the partial adjustment models, 6) and 7). The estimated short run elasticity is -.05 to -.07 while the long run response is from -.08 to -.1. The diversion program was operative on the corn acreage in the estimation period from 1966-1973 and in 1978. Based on equations estimated over earlier periods the Houck and McKeon studies generated elasticities at the mean in the range of -0.11 to -.13. Gallagher treats PV_2C independent of market price as in this study and estimates an elasticity of -.09.

The relative magnitude of the coefficient on the two corn program variables suggests an asymmetrically greater impact from 10¢/bu. for paid diversion versus a 10¢ decrease in the loan rate, target price or effect from a set-aside. In 1978 an effective 10¢ decrease in the effective support rate explains approximately a decrease of one million acres out of production. A direct payment of 10¢/bu. diversion however explains more than a four million acre reduction.

Substitutes

As the series of alternative models indicates the estimated results were mixed with respect to the role of wheat as an alternative for corn acreage. Particularly in areas well adapted for soft red winter wheat varieties, corn and wheat are substitutes (e.g. eastern corn belt). Nevertheless the impact today is less important relative to soybean than was true historically. Only in the partial adjustment models 6) and 7) was the t statistic on the wheat price coefficient greater than a 5 percent level of significance. The elasticity estimate in the short run is -.11 and -.156 in the long run. The only other study to include wheat price was McKeon's estimate, for which the full adjustment elasticity was -.157 which is equivalent to the estimate of this study.

The substitute relationship with soybeans is reflected in two aspects. The first is an estimated response to the change in the level of soybean prices. The second is an estimated response to the variability of corn price relative to soybean prices. The first aspect has been estimated in most other recent studies, however the second has not. The reasoning behind the second aspect is that uncertainty generated about corn prices due to volatility has reallocational significance to the risk averse producer if in fact less risky alternatives are available. For this reason it is appropriate to extend the standard price level basis for substitution to include the impact of uncertainty. If one were to base the structural estimate of substitution relationship on the price level alone, the elasticity estimate is evaluated at the mean in the range of -.13 and -.15. Houck et al generate a comparable elasticity estimate on soybean price of -.13 for 1950-74 data. Gallagher's study imposes an inverse transformation between the soybean market and support prices and generates a weak market -.01 elasticity on soybean price and a strong market elasticity, of -.10. Based upon Gallagher's definition of weak and strong markets, the soybean price elasticities vary in this study over the range of -.11 to -.16. These comparisons apply only to short run estimates. The LR elasticity estimated is -.19. Thus again substantial difference in the estimated responsiveness of farmers exists between this study and Gallagher's. Furthermore, as suggested above, these estimates do not reflect the substitution which arises out of changes in relative uncertainty over corn and soybean prices and therefore likely understate the responsiveness.

To what extent does the corn-soybean producer respond to soybean prices when market conditions change? To examine this aspect, it is suggested that the Gallagher typology be extended beyond the weak:strong market distinction by including stable:volatile market well. This defines a 2 X 2 framework which for our purposes consists of the relative corn/soybean price movement which is either stable or volatile. Based upon the following two time series: 1) the corn/soybean price ratio lagged one year and 2) the ratio of corn and soybean coefficient of price variations (based on price lagged one year to the average price in the previous three years), market conditions over the past decade can be categorized according to the strong:weak and stable:volatile typology.

Table 11. Classification of Corn Market Conditions relative to the Soybean Market, 1970-1978

Planting Decision Year	$\frac{\text{Corn price}_{t-1}}{\text{Soybean price}_{t-1}}$	$\frac{\text{Corn price C.V.}}{\text{Soybean price C.V.}}$	Market condition
1970	.49	.04	strong, stable
1971	.47	2.52	strong, volatile
1972	.36	5.40	weak, volatile
1973	.36	.12	weak, stable
1974	.45	1.12	strong, ----
1975	.45	2.14	strong, volatile
1976	.52	.03	strong, stable
1977	.32	1.98	weak, volatile
1978	.34	.48	weak, stable

Using an ad hoc break at .4 on the price ratio and 1.0 on the coefficient of variation ratio; every year (except perhaps 1974 when corn and soybean prices were similarly volatile) is rather easily characterized given the typology. The soybean cross price elasticity is estimated at the mean for observations of similar market conditions, the following table indicates the range of producer behavior implicit in the model 7).

Table 12. Soybean Cross Price Point Elasticity by Market Condition

Corn prices relative to soybean prices are:	Stable	Volatile
Weak	-.759	-.764
Strong	-.402	-1.563

These estimates suggest greater responsiveness in crop substitution in regards not only to changes in relative price levels but also changes in relative price movements. A further interpretation of the variable elasticity results can be made about the significant difference between the weak:volatile and strong:volatile market response. The idea of asset fixity with an assymetrically stronger adjustment response to upward price movement than to downward movement is reflected by the above results.

Corn Price

The market price of corn is specified as an explanatory factor of price expectations independent of price supports. As alluded to in the earlier discussion, corn price variability is also recognized. Comparisons of the various models result in several observations with implications for structural analysis.

The coefficient and elasticity for the market corn price variable is larger and more significant if wheat price is also included in the specification. This is demonstrated in models 1 through 4.

Model 3 tests the formulation of price variability only in terms of corn price. This variable is significant but as argued above, it does not reflect that uncertainty is relative to reasonable alternatives.

Elasticities estimated for earlier periods by Houck et al are in the range of +.12 to +.17. Whittaker and Bancroft estimate the elasticity on the basis of pooled time-series and cross-sectional data for a more recent period and obtain an elasticity estimate of +.22. This is identical to the SR elasticity estimated in models 6 and 7 of this study. The LR elasticities implied by these partial adjustment models is +.3. Again, however, this estimate does not include the total effect since the risk term has been ignored. Estimated at the mean, the SR elasticity response is +.19, which is lower than if the estimation ignores the effect of uncertainty. Based upon the procedure presented above with respect to the soybean cross elasticity under variable market conditions, the following table identifies the SR corn price elasticities implied by model 7, including the uncertainty term.

Table 13. Corn Own Price Point Elasticity by Market Condition

Corn prices relative to Soybean prices are:	Stable	Volatile
Weak	+.194 (1973, 1978)	+.457 (1972, 1977)
Strong	+.224 (1970, 1976)	+.203 (1974, 1975)

The changes in responsiveness under variable market conditions are not too different, except for the weak:volatile situation which is essentially one where the "bottom falls out of the market." The major turn around in corn prices in 1971 particularly relative to soybean prices, spurred a substantial decline in corn acreage. It suggests an asymmetically large reaction to large price declines. This is embodied in the negative sign on the coefficient of the price uncertainty term. To a degree, it is also contrary to the notion of asset fixity. However, with regard to the emphasis here on substitution as already reflected in the elasticity estimates on soybeans, the constraints imposed by fixed assets on corn production are largely irrelevant given an attractive soybean market alternative. In summary, the empirical results presented above, depart significantly from estimates in previous studies. The impact of government programs upon crop acreage supply response is substantially less inelastic than reflected in earlier estimates. Both wheat and particularly soybean price responses are significant. The full adjustment response to soybean prices relative to corn is in the elastic range. Finally, the response to corn price and price uncertainty is less inelastic than earlier estimated, particularly when the market is sharply depressed. However, the estimate which excludes uncertainty effects likely overestimates the price responsiveness.

Wheat and Feedgrain Demand

Livestock-Feed Grain Relationships

The most important interface in the domestic model is the feed demand framework. This component links the livestock sector to the crop sector. The utilization of feed is determined by the number of livestock units and the rates at which they are fed. Wheat fed to livestock is estimated in a single equation. The feed grains (corn, sorghum, barley and oats) are aggregated in a derived demand framework based upon the estimate of grain consuming animal units and feed grain feeding rates per grain consuming animal unit.

The degree of aggregation in this framework is troublesome. Ideally disappearance of each feed grain by each of the livestock categories would be modeled. Feeding rate levels are different and have changed over time differently for the various livestock classes. Similarly while the feed grains are substitutable to a degree, certain livestock feeds use one feedgrain over another within a range of relative price movement. The primary limitation in developing the more detailed model is that the USDA has to this point been unable to develop a constant historical set of data which identifies feed consumption by species of livestock and feedgrain.

Feed Grain Demand

The derived demand framework is determined by the multiplication of grain consuming animal units and feedgrain consumption per grain consuming animal unit.

Grain Consuming Animal Unit

This variable is based upon a weighted sum of the livestock units and is designed to be consistent with the USDA time series of the same name. The relative weights used in this model are the following:

Table 14. Weighted Composition of a Grain Consuming Animal Unit

Livestock Species	Weight	Unit
Beef Cow Inventory	0.1294	thous. head
Dairy Cow Inventory	1.000	thous. head
Dairy Heifer Inventory	0.21197	thous. head
Steer and Heifer Slaughter	1.288966	mil.lb.(dressed wt.)
Pork Production	1.11711	mil.lb.(live wt.)
Broiler Production	0.7349	mil.lbs. (RTC)
Turkey Production	1.1279	mil.lbs.(RTC)
Egg Production	1.7951	mil.doz.

Each of the livestock estimates above are based upon a calendar year time series. However the crop sector is modeled on a crop year. Thus the two frameworks are not synchronized in the t period as depicted in the following diagram.

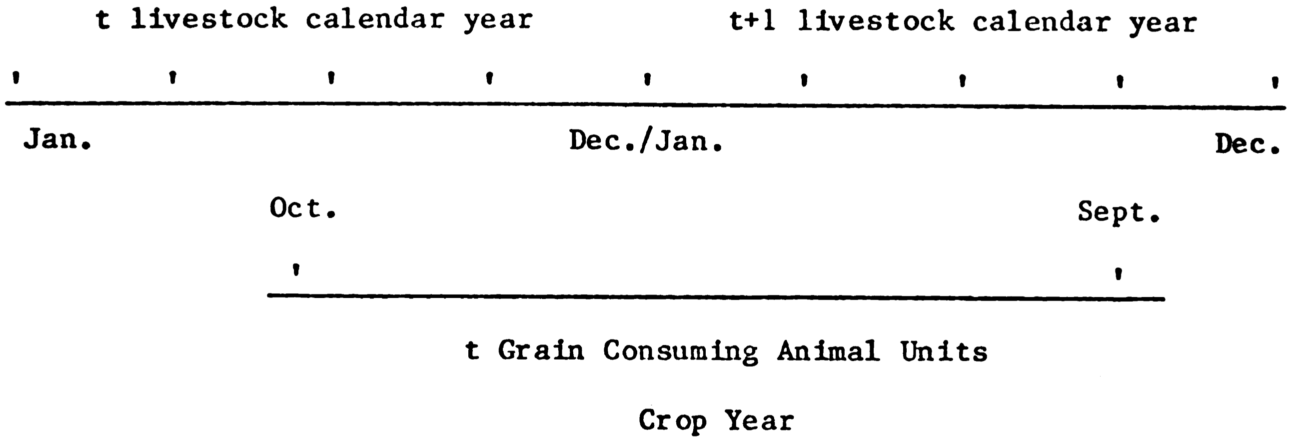

Figure 3. Livestock and Crop Years of the Model

In order to synchronize the individual livestock estimates to an aggregated grain consuming animal unit figure, the individual livestock classes are estimated for the next calendar year (t + 1) using the same set of estimated supply equations.

Since all explanatory variables for livestock supply equations are predetermined due to the recursive nature of their specification, every explanatory variable can be led forward one period. The alternative to this specification within the annual framework is to transform all of the livestock data and estimation period to a crop year basis. This is a less attractive approach for several reasons. First it must rely upon internally aggregating monthly or at least quarterly data series since the USDA standard annual series for livestock are calendar year basis. Second, from a user's viewpoint model output should be as consistent with standard USDA series as possible in order to make comparisons.

A concern which some may have with the formulation specified here is that there is a three month overlap using the annual model based on crop and calendar year commodities.

However, for an annual model there is no gain in identification by modeling an identical period for livestock production and grain consumption. This is so because beef, pork and even most poultry slaughter beginning in January has been on feed at least through the previous three months. Thus no more is lost in the one quarter lapse than in a framework where the livestock and crop years are identical since feed disappearance in at least one quarter will be strongly related to the following quarter's livestock output. This loss of information could, of course, be prevented in a quarterly model.

Feed Grain Consumption Per Grain Consuming Animal Unit

This variable represents the annual grain feeding rate for a grain consuming animal unit. This aggregated framework relies upon the validity of a static relationship for feeding rate equivalents as reflected in the weighting scheme for grain consuming animal units (GCAU). As feed conversion efficiency and/or maintenance requirements change, at different rates, by livestock class over time, this static GCAU weighting framework loses validity.

Ideally the weighting scheme would incorporate the changes in feed grain conversion efficiency over time, resulting in a grain consuming animal unit figure which reflects these technical dynamics. This would have the effect of making the year-to-year variation in the standard feeding rate variable a better reflection of the demand characteristics associated with relative prices of feed and slaughter prices.

The specification of feed prices in the feedgrain demand framework includes corn and soymeal prices. In this regard, the aggregated model is particularly weak in terms of structural relationships. For non-ruminants, particularly poultry, one would expect the corn and soymeal to be fed in fairly fixed proportions reflecting complementarity. Yet for the ruminants a substitution of say more corn and urea in response to high soymeal prices reflects the substitutability aspect. Therefore the actual estimated relationship is unable to reflect a mixture of the high protein-corn relationship possible in a more detailed structure.

Output prices are included for livestock sectors which are assumed to be unable to adjust supplies to current prices except by feeding to lighter or heavier weights. This is characteristic of both the beef and hog sectors. The final aspect of the specification is what could be termed the habit persistence or inertia associated with changing feeding rates. A moving average of the lagged dependent variable is a measure of this phenomenon. The feed grain demand model is given in Table 15.

The empirical results suggest a relatively weak substitution relationship between corn and soymeal. The cross price elasticity is +.064 at the mean. The association with the hog and steer prices suggests that the adjustment in the pork sector is faster, with less reliance placed upon feeding to lighter or heavier weights. The steer price is very strongly associated with feeding rate variation. This estimate suggests that a 10 percent increase in steer price will raise feeding rates by over 5 percent. Finally the influence of habit persistence is significant. A summary of the estimated elasticities is presented in Table 20.

Wheat Demand for Feed

While wheat feeding is relatively insignificant both to total domestic feed consumption and total wheat disappearance, it is the significant source of variability in domestic wheat disappearance. Much

Table 15. Feed Grain Demand

Dependent Variable	Independent Variables					
	Intercept	CP_{t-1}	SBP_{t-1}	PV_1BG	PV_1S	FGAVE
Feed Grain Consumption per Grain Consuming Animal Unit	.177 (.21)	-.332 (.063)	.024 (.009)	.003 (.004)	.036 (.006)	.49 (.15)

Dependent Variable: Feed grain consumption by livestock, mil. tons

Independent Variables:

CP_{t-1}: deflated corn price received by farmers, \$/bu.

SBP_{t-1}: deflated soybean price recieved by farmers, 44% protein Decatur, \$/cwt.

PV_1BG: deflated price received by farmers for 7 market barrow and gilt, \$/cwt.

PV_1S: deflated price received by farmers for steer, Omaha choice, \$/cwt.

FGAVE: feedgrain fed per grain consuming animal unit, tons, average of previous 2 years.

Estimation Period: 1964-1978

Estimator: OLS

R^2 = .905
D.W. = 2.44
S.E./Mean = .0471/1.73 = 3%
T.P.E. = 3/14 = 21%

of the wheat fed is in the third quarter of the calendar year. This suggests a relative availability hypothesis.

New crop wheat will have been just harvested and feedgrain stocks are based only upon the old crop supplies (actually this is true only for corn and sorghum, barley and oats will have been harvested).

Thus if wheat production relative to ending feedgrain stocks is large, one may expect increased feeding of wheat. To the extent that average annual prices do not capture the shorter run dynamics of a single quarter, the specification for wheat fed is based upon relative corn and wheat prices, augmented by the relative availability hypothesis. The estimates for this equation are given in Table 16.

\ The empirical results indicates that the relative availability hypothesis reflected by the coefficient for FSOWP, is not strongly associated with the feeding variability of wheat. In fact statistical results are generally superior in an estimation which excludes this variable as presented in Table 17.

The wheat price elasticity in the equation given in Table 16 is 1.76 while in the second equation in Table 17 an elasticity of 1.81 is estimated. This estimate is substantially higher than one reported in another study based on a somewhat different specification (Budell). The binary variable for 1967 reflects a period when wheat feeding was far below a level which would have normally existed given the wheat/feedgrain relative prices. Strong wheat prices had been expected going into this period which never materialized. Many producers chose to enter the loan program rather than sell the wheat for feed.

Table 16. Wheat Demand as Feed, a Relative Availability Hypothesis

Dependent Variable	Independent Variables				
	Intercept	$\frac{WP_{t-1}}{CP_{t-1}}$	GCAUT	FSOWP	DV67
Wheat Demand as Feed	-926.8 (329.3)	-169.9 (61.7)	16.6 (13.8)	-18.4 (42.7)	-78.4 (41.8)

Dependent Variable: wheat consumption by livestock, mil. bu.

Independent Variables:

WP_{t-1}: wheat price received by farmers, \$/bu.

CP_{t-1}: corn price received by farmers, \$/bu.

GCAUT: grain consuming animal units, mil. units.

FSOWP: ending feed grain stocks (t-1)/ carry-in wheat stocks plus wheat production (t).

DV67: dummy variable = 1,1967; = 0, otherwise.

Estimation Period: 1964-1978

Estimator: OLS

R^2 = .778
D.W. = 2.33
S.E./Mean = 40/123 = 33%
T.P.E. = 4/15 = 27%

Table 17. Wheat Demand as Feed

Dependent Variable	Independent Variables			
	Intercept	$\frac{WP_{t-1}}{CP_{t-1}}$	GCAUT	DV67
Wheat Demand as Feed	-949.7 (293)	-163.1 (44.1)	16.8 (3.4)	-79.7 (38.4)

Dependent Variable: wheat consumption by livestock, mil. bu.

Independent Variables:

WP_{t-1}: wheat price received by farmers, \$/bu.
CP_{t-1}: corn price received by farmers, \$/bu.
GCAUT: grain consuming animal units, mil. units.
DV67: dummy variable = 1, 1967; 0, otherwise.

Estimation Period: 1962-1978

Estimator: OLS
R^2 = .793
D.W. = 2.39
S.E./Mean = 37.2/117.9 = 32%
T.P.E. = 4/16 = 25%

Food Demand

Human consumption of wheat and feedgrains in the United States has been steadily increasing at slow rates. This reflects the price and income inelasticities which are well known for this demand relationship. The estimated results are given in Table 18.

Residual feed grain disappearance includes food preparation and alcoholic beverage uses. The demand for prepared food and alcoholic beverages is hypothesized to be relatively strongly related to disposable income. A habit persistence hypothesis is represented by the lagged dependent variable. The income elasticity estimate is 1.3 which suggests the relationship is relatively elastic. The residual feed grain demand equation is presented in Table 19. Price and income elasticities for feed grain and wheat demands are summarized in Table 20.

Seed Demand

The purpose of a seed demand equation is to identify the disappearance of current year production for seeding in the following year. Seeding in the following year is determined by the seeding rate per acre and the number of acres. The seeding rate tends to be relatively constant although it has changed for some crops over time. However, in the current year there is no way to know how many acres are to be seeded in the next year. Thus to proxy the anticipated supply of acres we can observe the current market year price. Following the expected price hypothesis, a positive association between current price and seed disappearance is suggested. While the seed demand quantity-price relationship would appear to defy the law of demand it more truly reflects the derived demand associated with expected plantings and fixed

Table 18. Wheat Demand as Food

Dependent Variable	Independent Variables			
	Intercept	WP	DPCI	POP
Food Use of Wheat	-302.9 (355.1)	-11.8 (7.6)	.012 (.07)	3.97 (2.58)

Dependent Variable: Food use of wheat, U.S., mil. bu.

Independent Variables:

WP: wheat price received by farmers, $/bu.
DPCI: deflated per capita disposable income $.
POP: U.S. population, mil. head

Estimation Period: 1962-1978

Estimator: CORC
R^2 = .896
Rho = .68
(.18)
S.E./Mean = 11.5/535.8 = 2%
T.P.E. = 9/15 = 60%

Table 19. Residual Feed Grain Demand

Dependent Variable	Independent Variables		
	Intercept	Income	RFG_{t-1}
Feed grain Consumption	4952.5	6.72	.02
	(3379.5)	(1.12)	(.01)

Dependent Variable: Residual, food and alcoholic beverage use of feed grain, mil. bu.

Independent Variables:

Income = per capita disposable income

RFG_{t-1} = residual feed grain consumption, lagged one year.

Estimation Period: 1962 - 1978

Estimator: OLS

R^2 = .726
D.W. = 2.23
S.E./Mean = 9%
T.P.E. = 4/16 = 25%

Table 20. Price and Income Elasticities for Feed Grain and Wheat Demand

	Price of:	Corn	Soymeal	Wheat	Omaha Steer	7 MKT. Barrow & Gilt	Disposable Income
Quantity of:	Feed per GCAU	-.245	.064		.548	.043	
	Wheat for Feed	1.807		-1.807			
	Wheat for Food			- .037			0.068
	Residual feed grain demand						1.303

seeding rates. Furthermore, market price is not necessarily a useful proxy for certified seed (particularly certified hybrids) since both the production and marketing processes are significantly different.

The seeding rate is reflected in the estimated relationship with current planted acreage and a trend variable to reflect changes in plant densities over the estimated period. The specification for each crop's seed demand is thus identical, generalized as follows where:

$$\text{Seed Demand}_t = f\ (\log\ (\text{time}),\ \text{acres planted}_t,\ \text{price}_t)$$

The OLS estimation period for all equations was 1954-1978. These equations are presented in Table 21.

Table 21. Seed Demand Equations

Crop	Units Mil.Bu.	Intercept	Log of Time	Current Year Acres Planted	Current Own Price	D.W.	R^2	S.E. / Mean	as a %	T.P.E.	as a %
Corn	Mil.Bu.	-101.7	24.5	.00013	2.95	1.68	.901	1.05	7%	9/24	38%
		(8.5)	(1.9)	(.00003)	(.79)			14.07			
Oats	Mil.Bu.	78.42	-17.07	.002	4.25	1.99	.974	3.88	6%	7/24	29%
		(109.6)	(24.5)	(.0003)	(5.84)			66.57			
Barley	Mil.Bu.	48.12	-10.1	.001	.929	1.87	.840	1.75	9%	19/24	79%
		(32.2)	(6.9)	(.0003)	(1.42)			19			
Sorghums	Mil.Bu.	4.22	-.795	.00005	.234	1.91	.413	.3	13%	11/24	46%
		(2.88)	(.62)	(.0002)	(.138)			2.3			
Wheat	Mil.Bu.	-269.4	67.8	.00061	10.4	2.23	.848	5.04	7%	12/24	50%
		(49.4)	(12.4)	(.00015)	(2.19)			69.76			
Soybeans	Mil.Bu.	-361.95	94.26	.00018	1.64	1.59	.963	2.85	6%	4/24	17%
		(94.5)	(24.3)	(.0002)	(1.2)			43.92			

Grain Price Linkage System

The most important inputs into the domestic model from the international component are the wheat and corn export prices. The MSU Agriculture Model is structured to reflect that the world price determines the domestic price for wheat and feedgrains. There is of course the recognition of the role of the United States support price (loan rate) which essentially sets the floor for both world and domestic prices. However at price levels above the floor, the supply and demand configuration of the world exporting and importing nations bears heavily upon domestic United States prices. This of course reflects the integral nature of the United States as the major but less than dominating exporter of wheat and feedgrains. It also reflects that agricultural export policy has been treated with benign neglect by the United States government. Seeming opportunities for world market coordination by the handful of major exporting nations under United States leadership have been officially rejected by the United States. This framework thus supports the specification of an estimable relationship which links the domestic price received by farmers to the United States export price. The estimation would be a simple matter were it not for the fact that the margin between the two price series is not constant.

The framework for explaining the year-to-year variation in this margin is based upon structural relationships identified with domestic transportation costs and export price variability.

As transportation costs increase from the farm to the point of export, the farm level demand will shift downward. The export supply will contract and increase the export price. The relative incidence of the impact however depends upon the relative elasticities of the supply and demand functions. Farm level supply is essentially perfectly inelastic within the marketing year. Assuming the domestic and export demand functions are price responsive, the entire brunt of the transportation cost increase would be expected to impact upon farm prices.

The second aspect which impacts upon the export-domestic price is hypothesized to be the variability in export price from year to year. It is suggested that in moving from a normal supply-demand situation into one of relatively tight supplies that the domestic markets tends to over-react. In the face of tight supplies, the margin narrows. Speculative responses by both farmers and traders add to the pressure on the domestic price. To the extent that the domestic price is above the loan rate, overreaction to an increased supply outlook will widen the margin.

In addition to the speculative factors, the existence of decreasing cost structure for trading firms attempting to maintain market shares will support this margin movement in response to the direction of change in the supply and demand situation.

The specification for wheat price received by farmers is given in Table 22. The elasticity relationships between these explanatory variables are presented in Table 21. The estimated relationship for corn price (Table 23) is specified similar to the wheat price linkage.

The estimated equations support the expected relationships as discussed above. The rail freight rate index coefficients indicate that farm prices do decline relative to export prices in response to increases in the marketing costs, but far less than proportionately. For

Table 22. Wheat Price Linkage, Domestic to Export Prices

Dependent Variable	Independent Variables				
	Intercept	WEP	GRFRI	WPCH	DV77
Wheat Price Received	.118 (.22)	.901 (.058)	-.002 (.002)	.123 (.072)	-.493 (.156)

Dependent Variable: wheat price received by farmers, $/bu.

Independent Variables:

WEP: wheat export price, $/bu.
GRFRI: grain-rail freight rate index 1967 = 100
WPCH: first difference of current and lagged wheat export price.
DV77: dummy variable = 1, 1977; 0, otherwise.

Estimation Period: 1969 - 1978

Estimator: OLS

R^2 = .993
D.W. = 1.90
S.E./Mean = .125/2.529 = 5%
T.P.E. = 0/9 = 0%

Table 23. Corn Price Linkage, Domestic to Export Prices

Dependent Variable	Independent Variables			
	Intercept	CEP	GRFRI	CPCH
Corn Price Received	.249 (.141)	.845 (.062)	-.002 (.001)	.172 (.084)

Dependent Variable: corn price received by farmers, \$/bu.

Independent Variables:

CEP: corn export price, \$/bu.
GRFRI: grain-rail freight rate index 1967 = 100.
CPCH: first difference of current and lagged corn export price.

Estimation Period: 1969 - 1978

Estimator: OLS

R^2 = 989
D.W. = 2.71
S.E./Mean = .084/1.952 = 4%
T.P.E. = 0/9 = 0%

both wheat and corn the change in export price coefficient supports the hypothesis of narrowing margins in response to upward export price movement.

Other Feed Grain Prices

Sorghum, barley and oat prices change with the corn price. This transmission is not always proportional since any one or all may be in an over or under supply situation relative to corn. This relative supply factor is specified in terms of a share of the total feed grain production. The estimated specifications are identical for each crop and are presented in Table 24.

Both barley and sorghum prices change proportionately to changes in the corn price. The oat price adjusts less than proportionately. It is as well the least flexible in relation to its production relative to total feed grain production. Again, barley and sorghum appear to be closer substitutes with corn as reflected by the higher price flexibilities on production.

Table 24. Other Feed Grains Prices Linkage to Corn Price

Feed Grain Price	Intercept	Corn Price	Production as a Percent of Total Feed Grain	R^2	D.W.	$\frac{S.E.}{Mean}$	T.P.E.
Oats	.425 (.068)	.199 (.125)	-.655 (.824)	.753	1.18	$\frac{.08}{.69}$	3/17
Barley	.870 (.073)	.353 (.179)	-.6.39 (2.28)	.927	1.48	$\frac{.08}{1.1}$	3/17
Sorghum	.542 (.221)	1.547 (.071)	-4.358 (1.86)	.969	2.07	$\frac{.09}{2.03}$	2/17

Estimator: OLS

Estimation Period: 1960-1978

Table 25. Elasticity/Flexibility Estimates for Grain Price Linkages.

Price Received By Farmers	Wheat Export Price	Change in Wheat Export Price	Corn Export Price	Change in Corn Export Price	Grain Rail Freight Rate Index	Corn Price Rec'd by Farmers	Oat Prod. rel. Feed Grain Produced	Barley Prod. rel. to Feed Grain Produced	Sorghum Prod. / Feed Grain Produced
Wheat	1.087	.026			-.123				
Corn			1.006	.003	-.147				
Oats						0.783	-.072		
Barley						0.998		-.319	
Sorghum						0.968			-.235

Livestock Supply and Demand

Beef

The beef sector estimated for this model was specified to generate aggregated supply forecasts of steer and heifer slaughter, cow and bull slaughter, Omaha choice steer and commercial cow prices. This sector contributes to the identification of the other types of livestock supply and demand models as well as the feed sector.

The problem of data aggregation is perhaps more problematic for beef than for most of the other commodities. Slaughter data, for example, includes dairy slaughter in both the steer and heifer and cow and bull categories. A second problem which is especially of concern for the specification of the cow inventory equation is the aggregation by type and location of producer. Important structural characteristics such as this are not explicitly identified within the estimated equations. Nevertheless, it is important to recognize the aspects which are likely important for each equation but are excluded for various reasons.

Important changes in the supply structure of beef include both institutional and biological aspects. Biological factors include changes in reproductive efficiency such as changing age at calving, estrous sychonization, a change towards larger framed breeds, improved feed conversion efficiency, development and use of nontraditional sources of feedstuffs (e.g. urea).

Structural aspects of the industry include most importantly, the shifting geographic concentration, changing size of feedlot enterprises and the increasing degree of integration in the production-marketing interface. Integration exists today from the range all the way through the retail hamburger chain outlet. In light of these institutional changes concern over beef pricing practices has developed.

Changes in the demand structure have been substantial over time. Retail demand has shifted as a result of changing life style characteristics, such as smaller households, working wives, and growth in discretionary incomes, which have favored highly processed or "fast" food.

The marketing margin has increased with more processing activities and has tended to generate a downwardly rigid retail price, relatively unresponsive to changes in the farm level supply.

These various biological and institutional aspects are noted here because they are not explicit in the estimated equation.

The structure of the estimated supply equations is depicted in the block diagram on the following page.

The supply variables which are endogenous to the model include beef cow inventory, steer and heifer slaughter and cow and bull slaughter.

The supply of slaughter beef hinges upon the supply function of beef cows. The beef cow equation thus is critical to the time path of the beef sector and the entire model. Tables 26 through 28 present alternative specifications for beef cow inventory.

The specification of the equation in Table 26 reflects several important aspects of the breeding herd enterprise. The gross margin reflects the difference between the value of the major output and a proxy for the feed cost. This margin assumes a marketable calf of 400

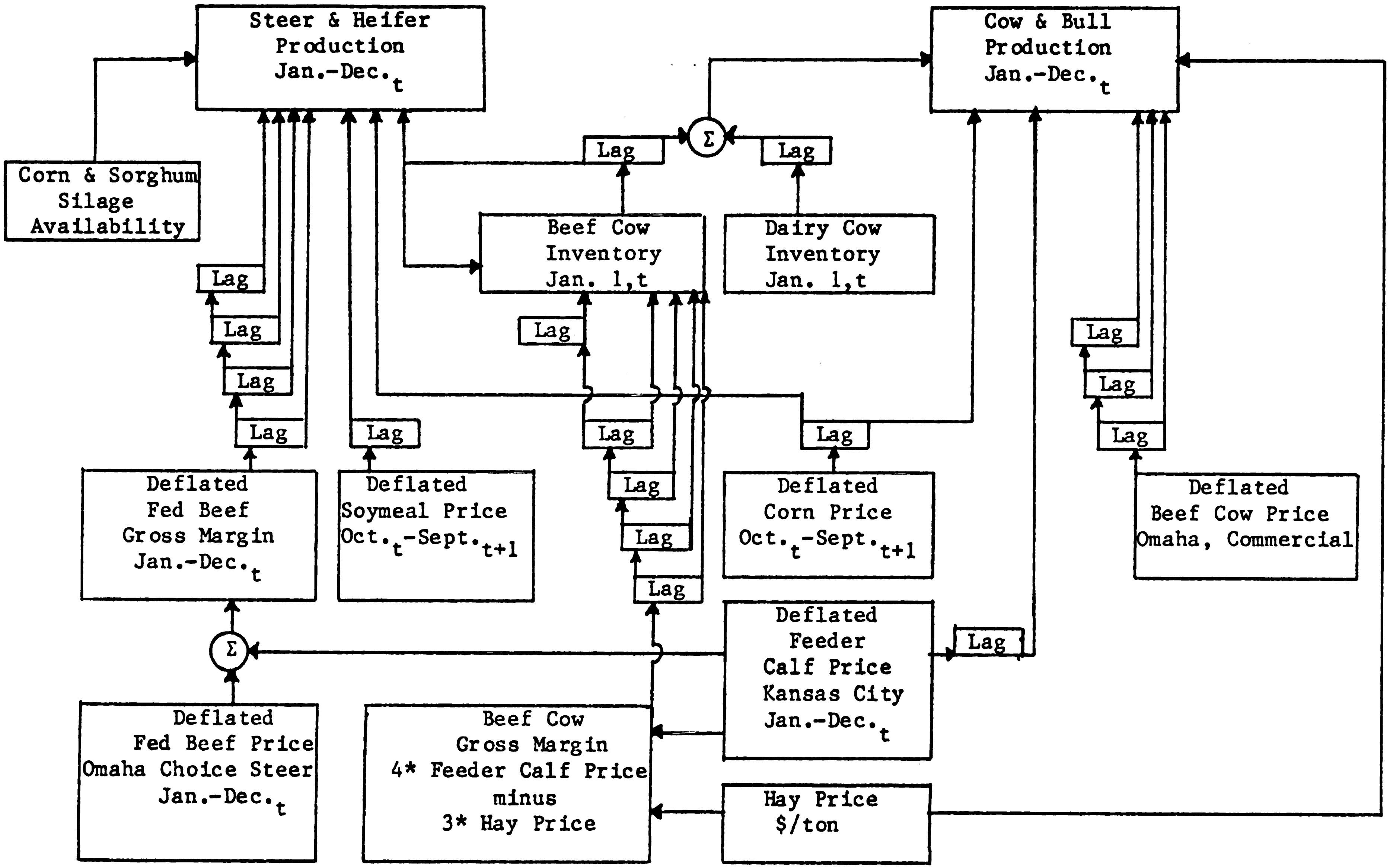

Figure 4. Diagram of the Beef Sector

Table 26. Beef Cow Inventory Equation (Symmetrical Lag Response)

Dependent Variable	Independent Variables							
	Intercept	BCI_{t-1}	CPI_{t-1}	$BFCGM_{(t-1)}$	$BFCGM_{(t-2)}$	$BFCGM_{(t-3)}$	$BFCGM_{(t-4)}$	$BFCGM_{t-5)}$
Beef Cow Inventory	518.1 (766.5)	.978 (.047)	-9.17 (10.45)	8.16 (4.80)	29.91 (5.38)	-1.37 (6.58)	8.16 (5.49)	1.89 (6.91)

Dependent Variable: Number of beef cows on farms on January 1, thous. head

Independent Variables:
- BCI_{t-1} = Number of beef cows on farms on January 1, thous. head, lagged one year.
- CPI_{t-1} = Consumer Price Index lagged one year (1967 = 1.0).
- BFCGM = 4.0 * KCFCP - 3.0 * HP
- KCFCP = Kansas City Feeder Calf Price, $/cwt.
- HP = Hay Price, $/ton.

Estimation Period: 1945 - 1979

Estimator: HILU

$R^2 = .997$

Rho = .40
(.17)

S.E./Mean = $\frac{517}{31903.5}$

T.P.E. = 1/28

lbs. and 3 tons of hay per year per cow. Again it should be noted that in some major cattle regions the structure of this margin would poorly reflect the nature of the cost structure. An important factor for the enterprise is the carrying cost of a cow. This is proxied by the price index to reflect the opportunity cost to the enterprise.

The lag structure associated with the gross margin is estimated for five years. It is depicted in Figure 5.

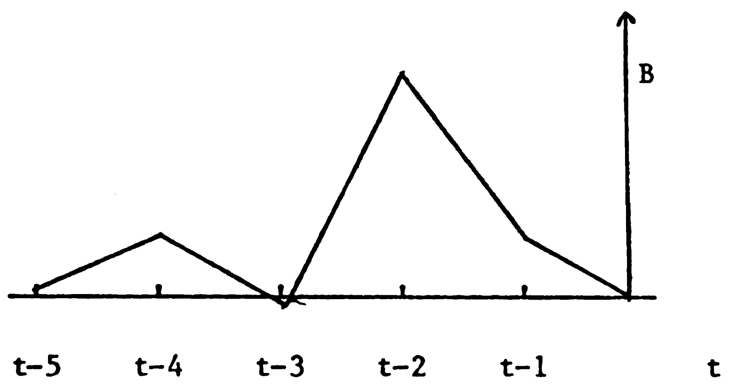

Figure 5. Lag Structure of Gross Margin Estimated Coefficients for Beef Cow Inventory.

This estimated lag structure appears to be a reasonable reflection of the biological delays associated with producer response. The breeding herd numbers can be altered very little immediately. Culling rates can be adjusted and decisions about yearling replacements can impact within one or two years. The major response is associated with the decision to hold heifer calves for replacement. These heifers will not have calved in general until two years have passed. The second but dampened pulse in the estimated lag structure reflects the multiplier effect of additional inventory resulting from the maturation of heifer calves born to replacements held originally.

The specification here implies an assumption of a symmetric supply response to upward and downward market signals.

This hypothesis was tested directly by separating expansionary market signals (upward prices or margins) and contractionary signals (downward prices or margins) into two separate explanatory variables. The equation in Table 27 is comparable to the one presented in Table 26 and provides evidence that an asymmetrical supply response exists.

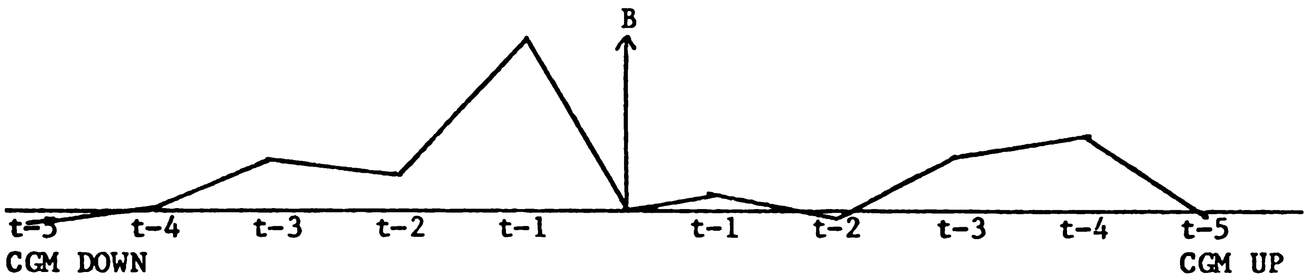

Figure 6. Lag Structure of Gross Margin Estimated Coefficients for Beef Cow Inventory

This decomposition indicates strikingly different lag structures associated with expansionary or contractionary signals.

The upward margin lag structure identifies the very small short term response which is possible for the producer. The primary impact does not come until the end of two years and actually peaks in the third year. On the other hand, the downward margin variable measures the primary impact in the first year since producers can cull a cow much faster than they can raise replacements. The identification suggests that use of a lag structure based upon a symmetric specification would probably underestimate the rate of contraction and overestimate the rate of expansion. It should be noted that the sign of the coefficient on the CPI variable changed from negative to positive with this specification change. An additional concern with the general specification was that the hay price data predominantly reflects forage costs in the Great

Table 27. Beef Cow Inventory Equation (Asymmetrical Lag Response)

Dependent Variable	Independent Variables							
	BCI_{t-1}	T	CPI	CGM_{t-1}	CGM_{t-2}	CGM_{t-3}	CGM_{t-4}	CGM_{t-5}
Beef Cow Inventory	.75 (.11)	223.0 (158.1)	29.07 (19.56)	UP 3.76 DOWN 39.9	UP -1.27 DOWN 7.61	UP 14.40 DOWN 11.67	UP 18.40 DOWN .38	UP -2.34 DOWN -9.81

Dependent Variable: Number of beef cows on farms on January 1 in year t minus the number on January 1, 1945.

Independent Variables: BCI_{t-1} = Beef Cow Inventory, lagged one year.

T = Year -45, equivalent to the intercept in the symmetric specification.

CPI = CPI in year t minus CPI in 1945, lagged one year.

$$\text{CGM-UP} = \sum_{i-0}^{t} (A_t - A_{t-1}) \text{ where } A_t - A_{t-1} > 0, \text{ and } A = 4.*\text{KCFCP} - 3.*\text{HP}.$$

$$\text{CGM-DOWN} = \sum_{i=0}^{t} (A_t - A_{t-1}) \text{ where } A - A_{t-1} < 0.$$

Estimation Period: 1945 - 1979

Estimator: HILU

R^2 = .998

Rho = .50
(.16)

S.E./Mean = $\frac{472}{31908}$

T.P.E. = 2/28

Lakes state dairying region and was really an unsatisfactory measure of forage costs for the national beef herd.

Thus in the equations presented in Table 28, the hay price was dropped and the gross margin replaced by the feeder calf price. The results were not significantly different in explanatory power and given the absence of a well developed forage component in the model, this specification is preferred. Both the symmetric and asymmetric lag structure specifications will again be presented to contrast the significantly different results.

The original specification of the slaughter equations as given in Figure 4 were estimated and tested in the model. While they are statistically well fit to the historical period; forecasts, while not unreasonable, did not reflect well the important linkage between cow inventory and thus what is, in the final analysis available for slaughter. In fact, slaughter forecasts could be larger than what was biologically plausible. The simple aggregated model presented here is inadequate in identifying the biological bounds which would adhere closely to a balance sheet.

The steer and heifer slaughter equation in Table 29 identifies the relationship of slaughter to beef cow inventory in the previous year and the supply response to feed prices, silage availablility and the profit margin between slaughter and feeder prices.

The linkage to the cow inventory is not exact in a biological sense. Feed prices are estimated independent of the feeder calf slaughter prices margin. Silage production is helpful to explain the availability of roughages for the feeding operation. The intercept shift estimated for the period after 1971 reflects the leveling off in the

Table 28. Beef Cow Inventory Equations (Symmetric and Asymmetric) with Feeder Calf Price Lag Response

Dependent Variable	Independent Variables							
	Intercept	BCI_{t-1}	CPI	$KCFCP_{t-1}$	$KCFCP_{t-2}$	$KCFCP_{t-3}$	$KCFCP_{t-4}$	$KCFCP_{t-5}$
Beef Cow Inventory								
Symmetric	506.1	1.09	75.8	61.4	118.0	20.7	30.3	18.7
Assymetric	259.3	0.833	-28.21	UP 38.4 DOWN 7.31	UP 38.4 DOWN 195.23	UP -26.4 DOWN 58.94	UP 84.54 DOWN 57.62	UP 97.76 DOWN 59.03

Dependent Variable: Number of beef cows on farms on January 1 in year t minus the number on January 1, 1945.

Independent Variables: Variables are defined exactly as in Tables 26 and 27 with appropriate differences for symmetric and asymmetric specifications.

Estimation Period: 1947 - 1979

Estimator:	Symmetric OLS	Assymmetric OLS
R^2 =	.996	.998
D.W. =	1.49	1.87
S.E./Mean =	$\frac{559}{32386}$	$\frac{431}{32386}$
T.P.E. =	1/27	1/27

A comparison of the lag structures:

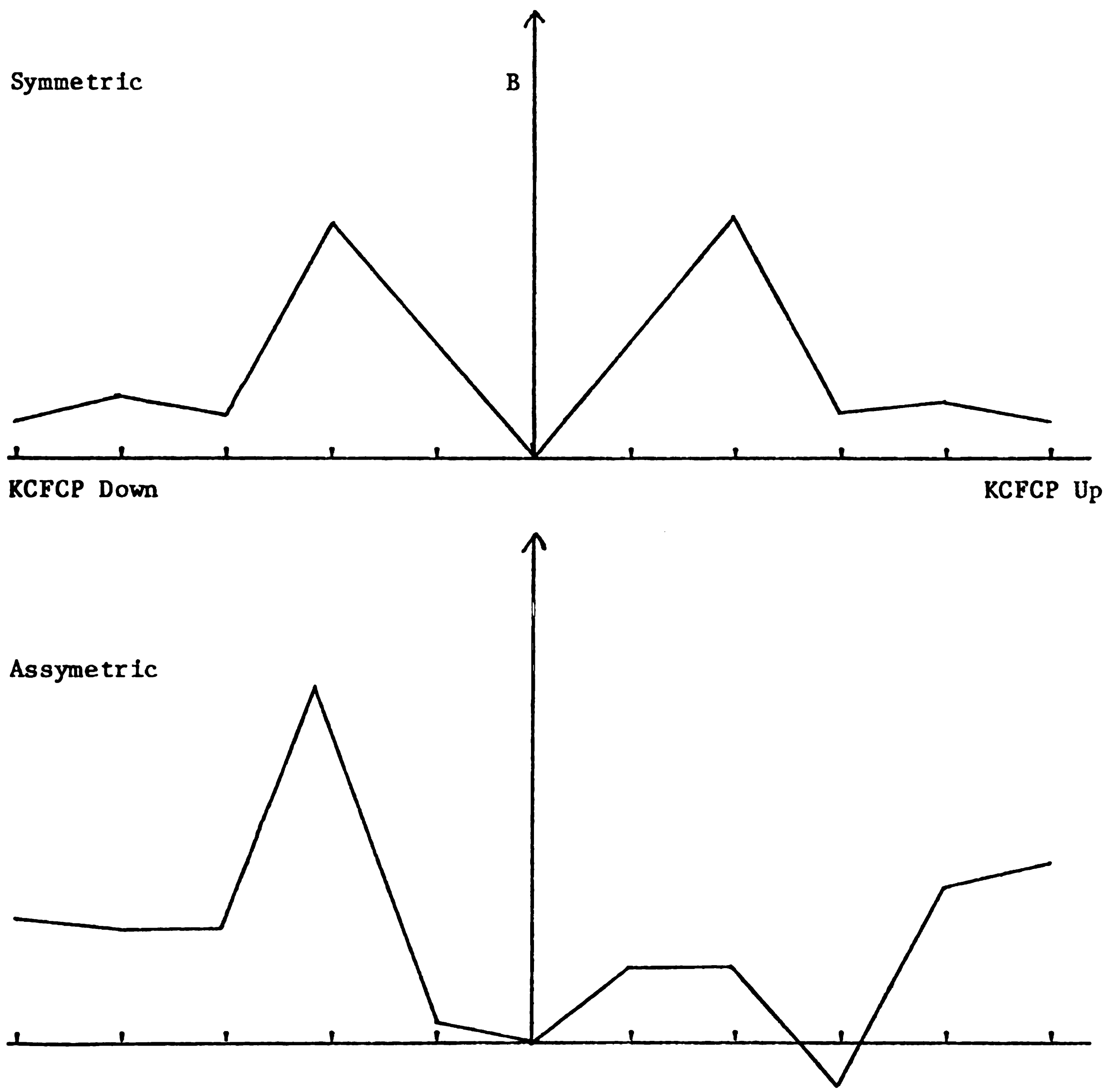

Figure 7. A Comparison of Symmetric and Asymmetric Lag Response Structures of Feeder Calf Price for Beef Cow Industry

Table 29. Steer and Heifer Slaughter

Dependent Variable	Independent Variables									
	Intercept	BCI_{t-1}	CP_{t-1}	SMP_{t-1}	$CSSP_{t-1}$	$FBFGM_{t-1}$	$FBFGM_{t-2}$	$FBFGM_{t-3}$	$FBFGM_{t-4}$	DV_{72} ON
Steer and Heifer Slaughter	1120.1	-.285	-2037.3	-231.9	0.0717	71.5	42.7	15.0	-11.43	-12067.8
	(4262.3)	(.106)	(550.5)	(77.4)	(0.03)	(24.7)	(31.1)	(27.9)	(12.5)	(4213.6)

Dependent Variable: Steer and heifer slaughter, dressed weight Jan-December

Independent Variables: BCI_{t-1} - Beef Cow Inventory, lagged one year.

CP_{t-1} - Corn price, deflated, lagged one year.

SMP_{t-1} - Soymeal price, deflated, lagged one year.

$CSSP_{t-1}$ - Corn and Sorghum Silage production, lagged one year.

FBFGM - Fed beef gross margin = 2.5, Omaha choice steer price/cwt. deflated - Kansas City feeder calf price/cwt., deflated.

DV_{72} ON - Dummy variable = 1, 1972 through forecast; = 0, otherwise

Estimation Period: 1954 - 1978

Estimator: CORC (Polynomial distributed lag)

R^2 = .987
Rho = .91
(.09)
D.W. = 2.33
S.E./Mean = 470/16018 = .03
T.P.E. = 5/21

tremendous growth and expansion in the fed-beef industry. This specification proved to be of questionable value over the forecast period since estimates could not be easily shown to be consistent with the projection of the inventory equation.

The identification of the slaughter number and their slaughter weight is an alternative specification which does impose consistency with the inventory of beef carrying into the slaughter period. This specification can be described by the explicit recognition of both the biological and decision processes.

The process begins with the decision to breed or cull. Cows not culled will be bred; the calving rate is determined by various factors such as successful breeding and other management skills. The same factors operate along with weather determine the calf survival rate. Dairymen will make an immediate decision whether to sell the bull calf for veal or retain for feeding. In most cases, all heifers will be retained for replacement with the exception of free-martin heifers from multiple births including both sexes.

The beef operator will typically allow the calf to nurse for several months at which time the calf might be sold for veal. Once the remaining calves are raised to feeder market weights, the producer must decide whether to retain the heifer calves for replacement. All calves destined for finishing can either be sold immediately to the finishing operation or held back to further grass feed and later be finished to slaughter weight. Total slaughter volume is then a function of feedlot survival rate and the average weight to which they are finished. Profitability in response to meat and feedlot production expenses will influence slaughter weight levels. This alternative model requires considerably more explicit information. Estimable relationships include calving rates, calf survival rates, replacement rates, veal slaughter, feedlot survival rates, and dressed weight rates. The trade-off of more estimation and information is the opportunity for greater consistency among forecasts of the breeding herd and the slaughter volume.

The other model supply variable is the cow and bull slaughter. Again a relatively simple aggregated equation was estimated, as presented in Table 30. It too has the weakness of potential incosistency with changes in the cow herd.

The estimated results appear to reasonably reflect the important influences regarding the cull decision. Year-to-year variation is significantly explained by changes in the national herd inventory. Culling would be expected to be positively influenced by increases in feeding costs reflected in the corn and hay prices. On the other hand, culling would be expected to be negatively related to changes in the price at which feeder calves sell. Finally a higher cow cull price tends to encourage higher culling rates. All of these relationships are reflected in the estimated equation. The use of a polynomial distributed lag structure for the cow price is probably unnecessary given the shortness of the lag and its geometric configuration.

A formulation of the cow and bull slaughter consistent with the alternative biological framework developed for steer and heifer slaughter would rely upon an estimation of the culling rate. In terms of an identity:

$$\text{Cull Cows}_t \equiv \text{Cow Inventory}_t - \text{Cow Inventory}_{t+1} + \text{Replacement Yearlings}_t$$

Table 30. Cow and Bull Slaughter

Dependent Variable	Independent Variables							
	Intercept	CI	CP_{t-1}	$KCFCP_{t-1}$	HP_{t-1}	$OCCP_{t-1}$	$OCCP_{t-2}$	$OCCP_{t-3}$
Cow and Bull Slaughter	-2980.6 (1015)	0.12 (.02)	880.5 (293.2)	-96.6 (29.6)	37.8 (24.1)	88.5 (54.5)	33.6 (23.0)	-21.4 (20.5)

Dependent Variable: Cow and bull slaughter, dressed wt. Jan.-Dec.

Independent Variables: BCI - Beef and dairy cow inventory Jan. 1, lagged one year.
CP_{t-1} - Corn price, deflated lagged one year
$KCFCP_{t-1}$ - Kansas City feeder calf price deflated lagged one year
HP_{t-1} - Hay price, deflated lagged one year
OCCP - Omaha commercial cow price, deflated, lagged.

Estimation Period: 1954 - 1978

Estimator: OLS (Polynomial Distributed Lag)
R^2 = .953
D.W. = 2.02
S.E./Mean = 240/3897
T.P.E. = 5/21

This variable could be regressed against essentially the same variables as in the original equation presented in Table 30.

The demand model for beef consists of three equations explaining the Omaha choice steer and commercial cow prices and the import demand for non-fed beef. Complete utilization of beef meat is assumed in the current calendar year.

The market prices are specified in response to beef supply conditions including both steer and heifer and cow and bull slaughter, supplies of close substitutes, per capita disposable income and the consumer price index. The price index was tested for independent explanation. The dependent variable is deflated by the CPI but this implies that a given change in the CPI results in a corresponding change in the steer price.

The CPI may be interpreted as an exchange rate with the rest of the economy approximately measuring the terms of trade, inasmuch as no one commodity dominates the index. The estimated relationship thus reflects the historical ability of the commodity price to maintain its relative value among the bundle of goods reflected in the price index. The specified equations as presented in Tables 31 and 32. The estimated equation generates statistically significant coefficients for nearly all variables.

Import quotas govern the quantity of low grade beef allowed into the United States. The 1964 Meat Import Act, amended, limits imports to approximately 8 percent of United States beef supply. The quota is explicitly modeled in the structure according to legislated formula. Imports of low grade beef are otherwise generated by an estimated equation expressed in terms of the domestic commercial cow price and

Table 31. Omaha Steer Price

Dependent Variable	Independent Variables						
	Intercept	SHS/POP	CBS/POP	PS/POP	DPCI	CPI	DV_{77}
Steer Price	48.4 (11.1)	-.513 (.08)	-.515 (.16)	-.11 (.08)	.017 (.002)	-5.63 (1.69)	-2.93 (1.0)

Dependent Variable: Deflated Omaha choice steer price, $/cwt.

Independent Variables: POP - U.S. Population, mil.
SHS - Steer and heifer slaughter, mil. lbs.
CBS - Cow and bull slaughter, mil. lbs.
PS - Pork slaughter, mil. lbs.
DPCI - U.S. disposable per capita income
CPI - Consumer price index
DV_{77} - Dummy variable; = 1, 1977; = 0, otherwise

Estimation Period: 1961 - 1978

Estimator: OLS
R^2 = .927
D.W. = 1.75
S.E./Mean = .85/26.64
T.P.E. = 2/17

Table 32. Omaha Commercial Cow Price

Dependent Variable	Independent Variables				
	Intercept	SHS/POP	(CBS + NFBI)/POP	LPCDI	DV_{73}
Cow Price	-157.1 (78.5)	-.211 (.14)	-.559 (.14)	26.06 (11.7)	3.92 (2.3)

Dependent Variable: Omaha commercial cow price $/cwt. deflated by CPI

Independent Variables: SHS - Steer and heifer slaughter, mil. lbs.
CBS - Cow and bull slaughter, mil. lbs.
NFBI - Non-fed beef imports, mil. lbs.
POP - U.S. population, mil.
LPCDI - Log of percapita disposable income
DV_{73} = Dummy variable = 1, 1973; 0 otherwise.

Estimation Period: 1961 - 1978

Estimator: CORC
R^2 = .786
Rho = .386
(.22)
S.E./Mean = 1.37/17.46
T.P.E. = 7/16

disposable income. This equation is given in Table 33.

Several variables in the beef sector which were treated exogenously over the historical period are forecasted on the basis of estimated equations. These variables then become endogenous to the model over the forecast period. The hay and feeder calf prices are modeled in this manner. The feeder calf price is associated with the recent profitability in cattle feeding business as well as current production costs and product prices. This equation is given in Table 34. The hay and forage sector in general is poorly identified in this model. The specification of the forecast equation is based upon demand considerations as was the feeder calf price. Its simple formulation follows the reasoning that with fixed supplies of hay, the more cattle in inventory, the higher the price will be from year to year. The estimated results are presented in Table 35.

Table 33. Net Beef Imports

Dependent Variable	Independent Variables		
	Intercept	OCCP	PCDI
Beef imports	-2254.09 (455)	18.74 (14.7)	1.2 (.14)

Dependent Variable: Net U.S. beef imports (excludes veal), mil. lbs.

Independent Variables: OCCP - Omaha commercial cow price, deflated $/cwt.
PCDI - Per capita disposable income

Estimation Period: 1964 - 1978

Estimator: OLS

R^2 = .868
D.W. = 1.33
S.E./Mean = 148/1653 = 9%
T.P.E. = 4/14 = 29%

Table 34. Kansas City Feeder Calf Price Equation

Dependent Variable	Independent Variables				
	Intercept	CP_{t-1}	OCSP	FBGM	CPI
Feeder calf Price	-3.294 (3.2)	-15.11 (2.6)	1.32 (.2)	.138 (.18)	11.15 (7.3)

Dependent Variable: Kansas City feeder calf price (KCPKP) \$/cwt.

Independent Variables: CP_{t-1} - Corn price received by farmers, \$/bu.
OCSP - Omaha choice steer price, \$/cwt.
FBGM - Fed beef gross margin = $(2.5 * OCST_{t-1} - KCFCP_{t-1})$
CPI - Consumer Price Index

Estimation Period: 1959 - 1978

Estimator: OLS

$R^2 = .954$
D.W. = 1.95
S.E./Mean = 3.48/37.34
T.P.E. = 2/19

Table 35. Hay Price Equation

Dependent Variable	Independent Variables		
	Intercept	BCI	DCI
Hay Price	-52.0157 (12.2)	.0014 (.0002)	.00214 (.0004)

Dependent Variable: Deflated hay price, national, all types, $/ton.

Independent Variables: BCI - Beef cow inventory, January 1.
DCI - Dairy cow inventory, June 1.

Estimation Period: 1954 - 1978

Estimator: OLS

R^2 = .734
D.W. = 1.25
S.E./Mean = 2.26/26.64
T.P.E. = 11/24

Dairy

The dairy model consists of four equations. The supply component begins with an estimate of dairy heifers. Dairy cows are determined based upon an estimated lag structure of the national cow herd for two year old through seven year old cows. Milk production per cow is estimated and multiplied by dairy cows to generate total milk production. The demand component is highly aggregated such that it is completely described by a single milk price.

The relationship of the dairy component to the rest of the model is primarily focused upon the feed disappearance. As discussed in the beef sector, dairy steer calves contribute to steer and heifer slaughter. Dairy cow and bull culls are included in the cow and bull slaughter variable.

The structure of the dairy industry has drastically changed over time. Total milk production has increased approximately 6 percent from 1950 to 1979. While this increase would otherwise seem relatively small, it is important to recognize that this level has been maintained with far fewer cows and dairy farms. Table provides information about some of the important aspects which reflect the major adjustment in the dairy producing sector.

Table 36. Changes in Dairy Production, Number and Productivity, 1950 and 1979

	1950	1979
Total Milk Production (Bil. lbs.)	116.6	123.5
Total Cow Inventory (Jan. 1) (Mil. hd.)	22.0	10.9
Production per cow (lbs.)	5,300	11,440
Number of dairy farms (thous.)	3,648	414 (1975)
Labor (hrs.) per 100 lbs. milk	2.36	.41 (1977)
Feed concentrates (lbs.) per 100 lbs. milk	30.8	43 (1978)

Source: 1979 Dairy Producer Highlight. National Milk Producers Federation. USDA Agricultural Statistics.

The numbers above indicate the tremendous improvement in cow productivity achieved. A second important aspect is that herd size per farm has increased and dairy farms have become more specialized. Much less labor is used in modern automated dairy systems. Cows are fed much heavier rations. This suggests a shift toward greater relative importance of feed costs.

Without attempting to identify in detail many of the important structural changes and issues associated with the U.S. milk market, several need to be identified. Most of the United States fluid milk is pooled by producer coops which coordinate supplies and distribute according to Federal Milk Marketing Orders. The increasing coordination and development of this marketing approach has relied upon relatively cheap transportation over long distances from surplus to deficit regions. The longer term implications of higher transport costs may subject this marketing structure and inevitably the location of production in jeopardy.

A second aspect is that fluid milk pricing in the Federal Milk Marketing Orders is based upon the market price of the Grade B milk in the upper midwest States (Minnesota-Wisconsin price series). However, this particular regional market has been continually declining and appears to be of questionable use for pricing to reflect the competitve forces operating upon the dairy industry as a whole. Furthermore, government income and price policy for dairy farmers is tied closely to this same pricing mechanism. Indeed, the method of maintaining the partial parity price for the dairy farmer by the federal government operates through direct purchases by the USDA Commodity Credit Corporation of butter, nonfat dry milk and cheese at prices which do not allow the M-W price to fall below the supported level.

A final aspect of substantial importance to the dairy industry are changes in the consumption patterns. First, home milk delivery has substantially declined. This has had the effect of making milk purchases more directly and occasionally competitive for the consumers discretionary expenditure budget. Perhaps even more important is that demand for high fat dairy products has fallen drastically. While a shift in favor of low-fat products has partially offset this decline, the total per capita consumption has declined as the following figures document.

Table 37. Changes in Dairy Foods Consumption, 1955 and 1978

	1955 (lbs)	1978 (lbs)
U.S. per capita whole milk sales	269	162
U.S. per capita lowfat milk sales	18.6	91.8
U.S. per capita cream sales	8.6	5.5
U.S. per capita total fluid milk sales	296	259

Source: 1979 Milk Facts. Milk Industry Foundation, p. 10.

In light of these rather pessimistic aspects of consumption, there is no reason to doubt the capacity for overproduction by the United States dairy industry in the short term. Government policy as well as favorable feed prices have encouraged an abrupt halt in the decline of dairy cow numbers from the trend identified above. Milk production per cow can be expected to reflect the potential for year-to-year increases, made possible largely by high levels of genetic selection pressure and reproductive advances. Volatile feed prices can of course be expected to offset this production potential somewhat. The bottom line must finally reflect the burden upon dairy price policy. This policy process has not been modeled or even recognized in an exogenous fashion. It is obviously endogenous to the dairy sector and model results must then be interpreted with this in mind. The supply model is represented in a block diagram on the following page (Figure 8).

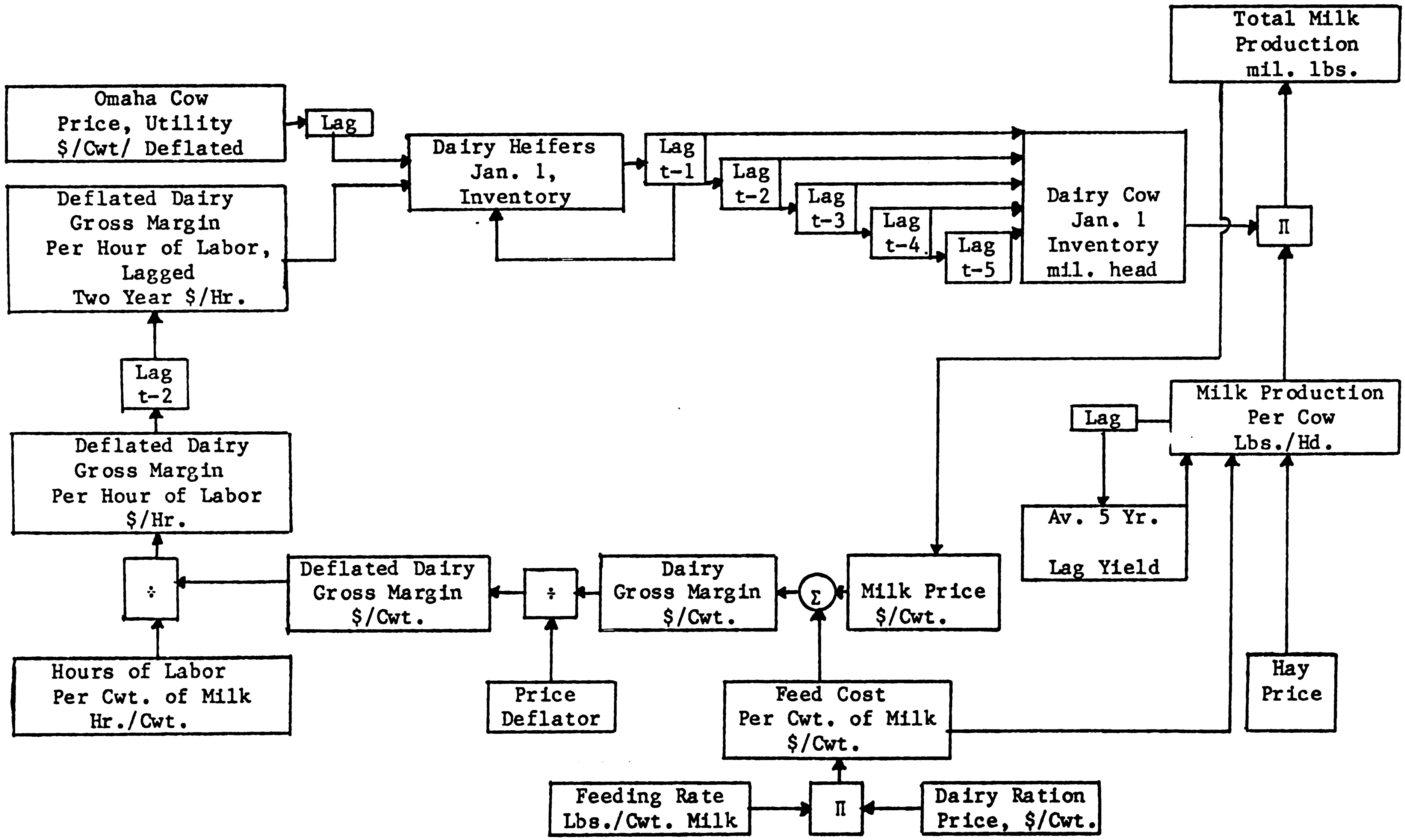

Figure 8. Diagram of Dairy Sector

Milk production is modeled as an identity based upon dairy cow inventories and milk production per cow. The dairy cow inventory is based upon relative weights multiplied by the number of dairy heifer replacements in the previous five years. The economic model is thus primarily focused upon the decision for dairy heifer inventory, and is presented in Table 38.

The empirical results statistically support the hypothesized relationship that profitability as proxied by the gross margin variable is important in the expansion/contraction decisions. This gross margin recognizes the biological two year delay between the time the cow is bred to the time the offspring is a yearling.

There are several important aspects captured in this gross margin. First the biological delay of the two years between the time the cow is bred until the offspring is a yearling is explicit. The information in the gross margin reflects the milk market, feed grain market, management practices and technological shifts. As an aggregated variable a gross margin affords degrees of freedom but implicitly imposes an assumption that the supply response is symmetrical to a proportional change in any one variable contained in the gross margin. The presumption that a supply response is symmetrical to changes in product and input prices was not investigated. The variables feeding rate, dairy ration cost, labor efficiency and utility cow price are forecasted based on equations identified at the end of this section on the dairy model.

As indicated above, the cow inventory is based entirely upon the estimates of 5 years of lagged heifer replacements. This model assumes that the age structure of the cows in the herd follows a fixed pattern and changes over time only in terms of changes in dairy heifer inventory

Table 38. Dairy Heifer Inventory Equation

Dependent Variable	Independent Variables				
	Intercept	DGM	DRP	DH_{t-1}	DV_{75}
Dairy Heifers	-288.5 (295.3)	31.86 (10.9)	18.74 (5.9)	.927 (.043)	187.8 (58.8)

Dependent Variable: Dairy Heifers, 500 lbs. and over, January 1, thous. head

Independent Variables:

DGM = (MP_{t-2} - (DRP * DCFR))/DLE
MP = All milk wholesale price, $/cwt., deflated
DRP = Dairy ration price, $/cwt. deflated
DCFR = Dairy concentrate feeding rate, cwt. feed/cwt. milk
DLE = Dairy labor efficiency, hr./cwt. milk.
DH_{t-1} = Dairy heifers, 500 lbs. and over, lagged one year.
DV_{75} = Dummy variable = 1, 1975; 0 otherwise.

Estimation Period: 1963 - 1979

Estimator: OLS

R^2 = .989
D.W. = 2.15
S.E./Mean = 56/4179 = 1%
T.P.E. = 1/16 = 6%

(Table 39). The lag structure appears to reflect a reasonable weighting scheme since one normally expects attrition from the cow herd to increase with age.

Milk production per cow has doubled since 1950. The average annual increase between 1950 and 1972 was 225 lbs. This uninterrupted increase was abruptly halted in 1973-74 when production per cow fell by 260 lbs. There is of course an obvious association to be made with the extremely high feed prices in those years. The milk yield equation is specified to reflect the current feed concentrate costs, roughage costs, cow inventory levels and a moving average of the lagged milk yield.

The estimated equation indicates significant associations with all explanatory variables. The sign of the hay price is positive which might appear unreasonable. However, all other things equal, a higher roughage cost will make concentrates relatively cheap and a shift in the total ration in favor of heavier concentrate feeding would have a positive production impact.

The cow inventory changes would be expected to be inversely related to the yield reflecting the culling pressure impact upon the more marginal producing cows. Milk production is identified in the model as an identity based upon the multiplication of the estimated dairy cow inventory and milk production per cow. The demand for milk is assumed to be represented by a single price equation. Of all the livestock outputs in the model this assumption is most inappropriate for milk since retail demand is relatively more differentiated. Fluid milk could be identified into high fat and low fat products. Manufactured products could be identified into cheese, dry milk, evaporated milk and frozen desserts. Another important demand is government related due to CCC

Table 39. Dairy Cow Inventory Equation

Dependent Variable	Independent Variables					
	Intercept	DH_{t-1}	DH_{t-2}	DH_{t-3}	DH_{t-4}	DH_{t-5}
Dairy Cow Inventory	7239 (1653)	.276 (.194)	.223 (.136)	.171 (.090)	.118 (.082)	.066 (.12)

Dependent Variable: Dairy Cows, January 1, thous. head.

Independent Variables: DH = Dairy Heifers, 500 lbs. and over, January 1, thous. head.

Estimation Period: 1963 - 1979

Estimator: CORC (Polynomial Distributed Lag)

R^2 = .995

Rho = .843
(.139)

S.E./Mean = 106/12205 = 1%

T.P.E. = 0/14 = 0%

purchases for price support operations. This specification could be expected to provide much more useful results for the dairy sector but given the needs of the aggregated model this level of detail was unwarranted.

Variables which are assumed exogenous but for which estimates are needed for the forecast of the dairy sector include the dairy ration price, dairy labor efficiency, dairy concentrate feeding rate and the utility cow price. The ration price, feeding rate, and cow price essentially become endogenous to the model since they are driven by other endogenous variables. The estimated equations are presented in Tables 42, 43 and 44.

The dairy ration price is estimated based upon the logical association with the prices of the two primary components of the ration, corn and soymeal. Since the crop year overlaps the calendar year, current and lagged prices for each feed were specified. The lagged crop year price overlaps 9 out of the 12 calendar year months, thus the estimated coefficients reasonably reflect this aspect in their weighted size and statistical significance. The current crop year corn price coefficient is not statistically significant and has an unexpected sign. The dairy concentrate feeding rate is expected to adjust to feeding prices and changes in management practices. The estimated equation (Table 44) attempts to reflect these aspects.

While time is generally a poor information proxy for explaining changes in management practices, the historical time series can be represented in a gross way by a simple logrithmic function. Thus as expected the log of time as an expendatory variable is powerful in the regression. The feed cost variable, however, is also significant and has the hypothesized inverse association. Dairy labor efficiency (Table 44) is based in an estimated forecast equation which is a function of log of time and farm wage rate. The Omaha utility cow price is specified in the dairy sector as a proxy for the salvage value of a cull. It is estimated over the forecast based upon a simple linkage to the Omaha commercial cow price which one would expect to be closely associated (Table 45).

Table 40. Milk Production Per Cow Equation

Dependent Variable	Independent Variables				
	Intercept	RCOST	HP	DCI	$MYLD_5$
Milk Production	5.946 (1.9)	-.0176 (.0045)	.038 (.021)	-.00017 (.00007)	.804 (.124)

Dependent Variable: Milk production per cow, thous. lbs.

Independent Variables:

RCOST = DRP * DCFR
DRP = Dairy Ration Price $/cwt. deflated
DCFR = Dairy Concentrate Feeding Rate cwt. feed/cwt. milk
HP = Hay price, all types, $/cwt. deflated
DCI = Dairy cow inventory, mil. head
$MYLD_5$ = Moving average of the previous 5 years of milk production per cow, thous. lbs.

Estimation Period: 1964 - 1978

Estimator: OLS

R^2 = .991
D.W. = 2.59
S.E./Mean = .118/9.634 = 1%
T.P.E. = 0/14 = 0%

Table 41. Milk Price Equation

Dependent Variable	Independent Variables		
	Intercept	MP/POP	USPCI
Milk Price	5.474 (3.02)	-.0063 (.0035)	.00097 (.00055)

Dependent Variable: Milk price, all milk wholesale, deflated, $/cwt.

Independent Variables: MP - Total U.S. milk production
POP - U.S. population
DPCI - U.S. per capita disposable income deflated

Estimation Period: 1954 - 1978

Estimator: CORC
$R^2 = .759$
Rho = .91
S.E./Mean = .174/5.04 = 3%
T.P.E. = 9/23 = 39%

Table 42. Dairy Ration Price

Dependent Variable	Independent Variables				
	Intercept	CP	CP_{t-1}	SMP	SMP_{t-1}
Dairy ration Price	.55 (.17)	-.14 (.27)	1.58 (.20)	.072 (.04)	.18 (.05)

Dependent Variable: Dairy ration price, $/cwt. nominal

Independent Variables: CP - Corn price received by farmers, $/bu.
SMP - Soymeal price, 44%, Decatur, $/cwt.

Estimation Period: 1961 - 1978

Estimator: OLS
R^2 = .974
D.W. = .173
S.E./Mean = .26/4.10 = 6%
T.P.E. = 1/17 = 6%

Table 43. Dairy Concentrate Feeding Ratio

Dependent Variable	Independent Variables		
	Intercept	TL	DRP
Feeding rate	-159.33 (11.0)	47.5 (2.8)	-.622 (.24)

Dependent Variable: Feeding rate, cwt. feed/ cwt. milk

Independent Variables: Trend, log (i) i = 54, ... 78.
DRP - dairy ration price $/cwt.

Estimation Period: 1954 - 1978

Estimator: OLS
R^2 = .959
D.W. = .51
S.E./Mean = 1.03/37.17 = 3%
T.P.E. = 4/24 = 17%

Table 44. Dairy Labor Efficiency Equation

Dependent Variable	Independent Variables		
	Intercept	LT	FWR
Dairy Labor Efficiency	26.11 (.4)	-6.09 (.10)	.275 (.02)

Dependent Variable: Hours of labor/cwt. of milk

Independent Variables: Trend, log (i) i = 54, ..., 78.
FWR - Farm wage rate, $/hr.

Estimation Period: 1954 - 1978

Estimator: OLS

R^2 = .998
D.W. = .5
S.E./Mean = .022/1.05 = 2%
T.P.E. = 0/24 = 0%

Table 45. Omaha Utility Cow Price Equation

Dependent Variable	Independent Variables
	OCP
Omaha Utility Cow Price	.984 (.014)

Dependent Variable: Omaha Utility cow price $/cwt.

Independent Variable: OCP: Omaha Commercial cow price $/cwt.

Estimation Period: 1967 - 1978

Estimator: CORC

R^2 = .992
RHO = .83
(.13)
S.E./Mean = .23/17.22 = 1%
T.P.E. = 0/16 = 0%

Pork

The supply and demand structure for pork can be represented to a large degree by the interrelationships between feed and meat prices. Production is determined by the size of the pig crop and the weights to which they can be economically fed, usually to a range between 220 and 240 lbs. per head. The farrow-to-finish process takes approximately six months. Thus to estimate pork supplies for the calendar year the model begins with an estimate of sows farrowing in the previous fall and farrowing in the spring of the current year. Based upon a fixed relationship between the estimated sows farrowed and pig crop, slaughter supplies vary in response to profitability, as determined by feed and hog prices. Information and biological lags contribute to a typical cycle in production which lasts approximately three to four years.

The hog price is generated out of a derived demand framework similar to that specified for all other livestock categories. Consumption is assumed to be identical to supplies and price adjusts to reflect supply-demand relationships.

Several important structural aspects in the pork sector have changed over the recent historical period. Some have been recognized in the model specification while others have not. Unlike beef production the volume of pork produced in the United States has been relatively stable. Between 1950 and 1977 pork production increased by 24 percent compared with a beef production increase of 165 percent. Per capita consumption of pork has averaged around 64 lbs. per year over this same period compared to a doubling of beef consumption which increased from 63 lbs. in 1950 to 126 in 1977. Thus pork has become relatively less important to the meat sector over the last two decades.

The size of enterprises has increased and the number of farms has declined. Perhaps the most significant structural aspect of hog production has been the growth in relatively capital intensive total confinement hog operations with a capacity to market over 100 hogs per year. As a percent of total marketed volume, this type of operation accounted for virtually none of the marketings in the early 50's but by the late 70's accounted for more than 40 percent of the volume.

The development of this production system is significant for several reasons. First it has tended to even out the seasonal supply of hogs. Farrowings in the 50's were split approximately 60 to 40 percent for spring/fall. Today that split is essentially 50/50. A second impact is that the increasing use of more capital assets in production increases the degree of asset fixity causing contraction to be more sluggish than expansion. This assymetry in the supply response is examined empirically below in the supply model estimation. Another important aspect of the change in production management is the tendency toward a faster turnover of the breeding herd. Average farrowings per sow have dropped from six or seven to four or five. The faster replacement schedule has the potential for attaining higher levels of productivity per sow in terms of faster genetic improvement.

With regard to demand, the growth in the share of beef in the consumers' meat diet has been an important influence upon pork demand. This aspect is measured empirically in the price equation. More recently an issue in pork consumption is the growing controversy over food additivies, specifically in the use of nitrite and nitrates in curing meats. It is not known to what extent this will become a major demand shifter. It was not introduced into the empirical analysis but should be considered in interpreting forecasts of future consumption patterns. A diagram of the pork supply model is presented on the following page (Figure 9).

The specification of the spring and fall farrowing equations are similar. Appropriate differences in lags of the explanatory variables are made to more closely reflect the dynamics of supply conditions. As with the beef cow inventory equation the major hypothesis that the supply function is symmetrical with respect to upward and downward price movement was tested for both spring and fall farrowing. These results will be presented below.

The general specification of the spring farrowing equation suggests the importance of partial adjustment based upon the previous year's inventory of sows, the competitive enterprise of feeding beef, and a gross margin which reflects changes in profitability in pork production. The fed beef price is a significant variable which reflects the important aspect of enterprise mix for hog production. For example, in 1975, 60 percent of farms that produced hogs also fed cattle.

With regard to the alternative specification of symmetry in supply response, presented in Tables 46 and 47, the null hypothesis is rejected at high levels of statistical significance. The corrected coefficients of determination provide one measure of this significance. t statistics also bear out significance in the difference between the coefficients for A and B on the fed beef price and C and D on the gross margin. Furthermore the supply elasticity is significantly greater for upward price movement than downward which supports the asset fixity hypothesis.

The specification of the fall farrowing equation differs from the spring farrowing in three ways. It keys off of only the most recent

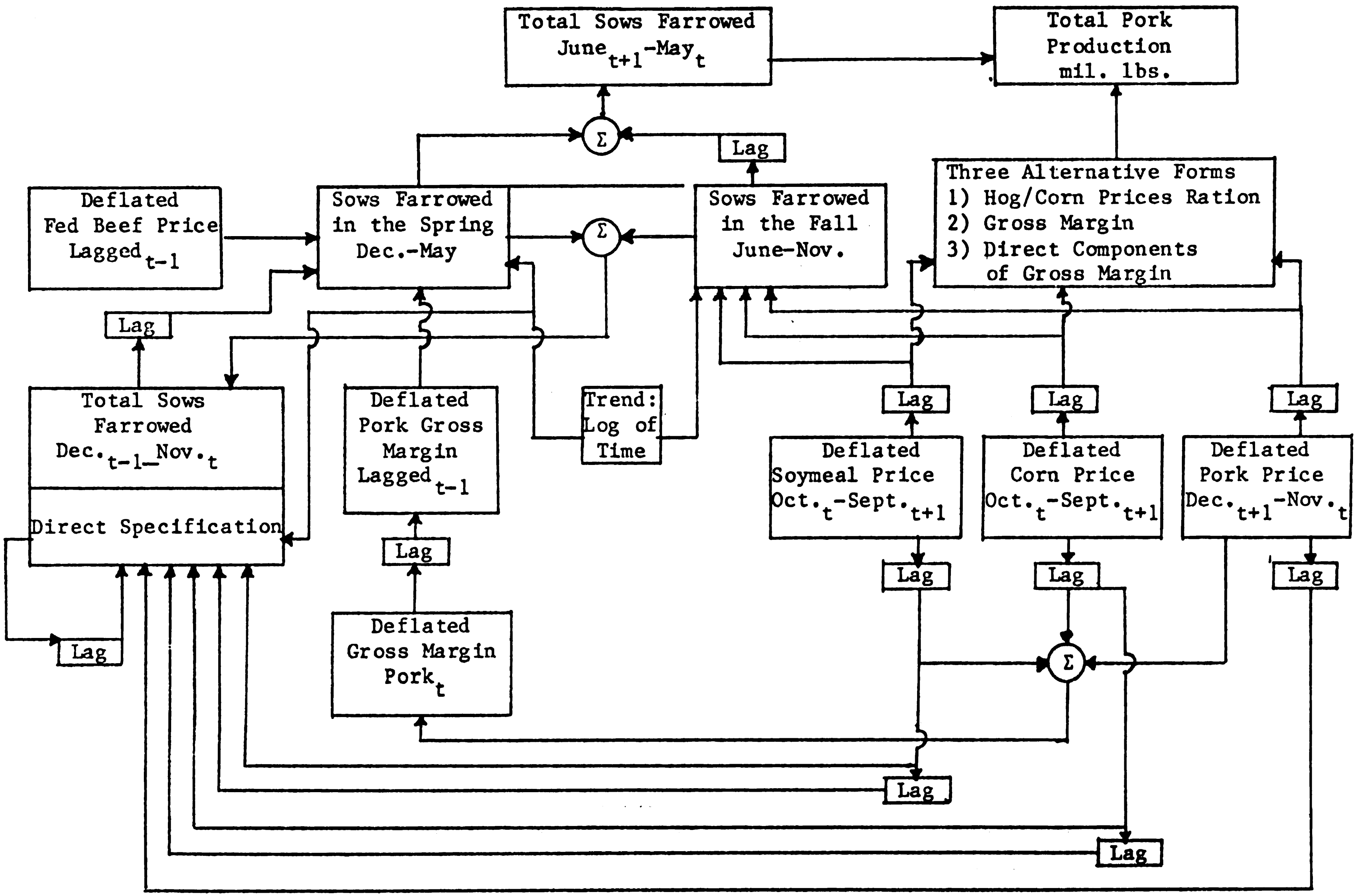

Figure 9. Diagram of the Pork Sector

Table 46. Sows Farrowing in the Spring Equation (Symmetric)

Dependent Variable	Independent Variables				
	Intercept	TL	TOTSOWS	OSP	DGMPORK
Sows Farrowing in the Spring	19092.1 (3380)	-4589 (761)	.59 (.07)	-75.8 (21.5)	157.6 (30.2)

Dependent Variable: Sows farrowing in the spring, Dec.-May, thous. head

Independent Variables:

TL = trend, log (i), i = 61, ..., 78
TOTSOWS = Total sows farrowing in Spring and fall, thous. head lagged one year
OSP = Omaha steer price. $/cwt.
DGMPORK = Gross margin for pork, defined as:
$HP_{t-1} - (6.0 * CP_{t-2} + 0.8 * SMP_{t-2})$
HP = 7 market hog and G H price $/cwt., lagged one year
CP_{t-2} = Corn price received by farmers, $/bu., lagged two years.
Y(74) = Soymeal price, 44% protein, Decatur $/cwt., lagged two years.

Estimation Period: 1960 - 1978

Estimator: HILU

$R^2 = .83$, $\bar{R}^2 = .78$
Rho = -.55
(.2)
S.E./Mean = 272/6431 = 4%
T.P.E. = 5/17 = 29%

Table 47. Sows Farrowing in the Spring Equation (asymmetric)

Dependent Variable	Independent Variables						
	T	TL	TOTSOWS	A	B	C	D
Sows Farrowing in the Spring	-859.2 (276.4)	45429 (17330)	.55 (.06)	-204.3 (37.8)	-37.7 (24.3)	238.1 (30.0)	69.0 (37.5)

Dependent Variable: Sows farrowing in the spring, Dec. - May, thous. head

Independent Variables:

T = i = 54, ..., 78
TL = Trend, log (i) - log (53), i = 54, ..., 78
TOTSOWS = Total sows farrowing in fall and spring, thous. head, lagged one year minus total sows farrowed in 1954.

$A = \sum_{i=0}^{t} (OSP_{t-1} - OSP_{t-2})$ where $OSP_{t-1} > OSP_{t-2}$

OSP Y(77) = Omaha steer price

$B = \sum_{i=0}^{t} (OSP_{t-1} - OSP_{t-2})$ where $OSP_{t-1} < OSP_{t-2}$

$C = \sum_{i=1}^{t} (DGMPORK_t - DGMPORK_{t-1})$ where $DGMPORK_t > DGMPORK_{t-1}$,
where DGMPORK is defined in Table 46

$D = \sum_{i=1}^{t} (DGMPORK_t - DGMPORK_{t-1})$ where $DGMPORK_t < DGMPORK_{t-1}$

Estimation Period: 1960 - 1978

Estimator: HILU

$R^2 = .92$ $\bar{R}^2 = .87$
Rho = -.69
S.E./Mean = 202/6431 = 3%
T.P.E. = 4/17 = 24%

farrowing period (spring) instead of the two most recent. It excludes the direct impact of fed beef, which is implicit however in the use of the spring sow estimate. Finally the gross margin is disaggregated into the independent components. More recent annual period feed prices are reflected in the fall farrowing decision than spring farrowings.

The empirical results presented in Tables 48 and 49 are mixed. The symmetrical model has expected and significant results for all variables. On the other hand, the assymetrical model is superior in explaining the historical data based on the $\bar{R}^2$, standard errors and turning point errors. Nevertheless unexpected signs for the coefficients of variables H, I, and J are estimated. One would expect the signs of E and F to be positive reflecting a positive relationship between supply and pork price. The fixed asset hypothesis further asserts E > F which is statistically valid in this equation. The coefficient signs of the feed price variables (corn, G and H and soymeal, I and J) would be expected to be negative. Only the coefficient for G is statistically significant and of the expected sign. In light of this result suggesting the unimportance of soymeal price, the assymetrical model was respecified in terms of upward and downward changes in the hog/corn price ratio. The equation representing this model is given in Table 50.

This model has significant and expected signs on all explanatory variables. However, the statistic for the significance of difference in the coefficients for P and N, i.e., the test of supply response symmetry is 0.356. Thus the null hypothesis is accepted, that symmetry does exist. These results for the hog sector therefore tend to indicate mixed support for the asset fixity hypothesis. One weakness of these models

Table 48. Sows Farrowing in the Fall Equation (Symmetric Response)

Dependent Variable	Independent Variables					
	Intercept	TL	Y(4)	HP_{t-1}	CP_{t-1}	SMP_{t-1}
Sows farrowing	-9172 (2843)	2609 (623)	0.65 (.09)	59.7 (15.1)	-851.1 (191.1)	-85.8 (31.2)

Dependent Variable: Sows farrowing in the fall, June–Nov., thous. head

Independent Variables:

TL = Log of time, i = 7, ... 25
Y(4) = Sows farrowing in the spring Dec.-May, thous. head
HP_{t-1} = 7 market Hog and Gilt price, $/cwt.
$CP_{t-\pm}$ = Corn priced received by farmers $/bu.
SMP_{t-1} = Soymeal price, 44% protein, Decatur,$/cwt.

Estimation Period: 1960 - 1978

Estimator: HILU

R^2 = .89 $\overline{R}$ = .843
S.E./Mean = 181/5880 = 3%
T.P.E. = 1/17 = 6%

Table 49. Sows Farrowing in the Fall Equation (Asymmetric Response)

Dependent Variable	Independent Variables								
	T	TL	Y(4)	E	F	G	H	I	J
Sows Farrowing in the fall	-859 (708)	41931 (43336)	0.64 (0.09)	155.5 (33.6)	109.5 (55.2)	-2551.3 (865.1)	448.8 (544.0)	15.4 (71.0)	115.2 (91.7)

Dependent Variable: Sows farrowing in the fall, June–Nov., thous. head

Independent Variables:

T = i - 53, i = 54, ..., 78
TL = Trend, log (i) - log (53) i = 54, ..., 78
Y(4) = Sows Farrowing in spring, Dec.-May, thous. head minus sows farrowing in spring, lagged one year

$E = \sum_{i=0}^{t} (HP_{t-1} - HP_{t-2})$ where $HP_{t-1} > HP_{t-2}$, HP = 7 market hog and gilt price, \$/cwt.

$F = \sum_{i=0}^{t} (HP_{t-1} - HP_{t-2})$ where $HP_{t-1} < HP_{t-2}$

$G = \sum_{i=0}^{t} (CP_{t-1} - CP_{t-2})$ where $CP_{t-1} > CP_{t-2}$, CP = corn price received by farmers, \$/bu.

$H = \sum_{i=0}^{t} (CP_{t-1} - CP_{t-2})$ where $CP_{t-1} < CP_{t-2}$

Table 49 (Cont'd)

$I = \sum_{i=0}^{t} (SMP_{t-1} - SMP_{t-2})$ where $SMP_{t-1} > SMP_{t-2}$, SMP = soymeal price, Decatur, $/cwt.

$J = \sum_{i=0}^{t} (SMP_{t-1} - SMP_{t-2})$ where $SMP_{t-1} < SMP_{t-2}$

Estimation Period: 1960 - 1978

Estimator: HILU

$R^2 = .95$ $\bar{R}^2 = .90$

Rho = −.56
(.20)

S.E./Mean = 145/5880 = 2%

T.P.E. = 0/17 = 0%

Table 50. Sows Farrowing in the Fall Equation (Asymmetric Response)

Dependent Variable	Independent Variables				
	T	TL	Y(4)	P	N
Sows Farrowing in the Fall	311 (181)	-20329 (11773)	0.66 (.08)	86.6 (10.0)	76.0 (34.9)

Dependent Variable: Sows farrowing in the fall, June-Nov., thous. head

Indepedent Variables:

$T = i - 53$ where $i = 54, \ldots, 78$

TL = Trend, $\log(i) - \log(53)$, $i = 54, \ldots, 78$

Y(4) = Sows farrowing in the Spring, Dec.-May, thous. head.

$$P = \sum_{i=0}^{t} (HCR_{t-1} - HCR_{t-2}) \text{ where } HCR_{t-1} > HCR_{t-2}$$

$$N = \sum_{i=0}^{t} (HCR_{t-1} - HCR_{t-2}) \text{ where } HCR_{t-1} < HCR_{t-2}$$

HCR = Hog/corn price ratio = HP_t/CP_{t-1}

Estimation Period: 1960 - 1978

Estimator: HILU

$R^2 = .90$ $\bar{R}^2 = .87$

S.E./Mean = 163/5880 = 3%

T.P.E. = 0/17 = 0%

is that they assume fixed parameters over the entire estimation period. As noted in the introductory comments, the production system has tended to become more capital-intensive. Perhaps a better model to test the asset fixity hypothesis would require estimation based upon a time varying parameters.

The model identifies pork slaughter in a rather awkward manner. Ideally the model would be essentially identical to the beef biological decision models discussed earlier. Lags would, of course, be shorter but a similar set of environmental, biological, and economic parameters would provide for a more complete and consistent model. Instead, the model here assumes essentially a fixed pigs farrowed per sow by relying upon a direct linkage from the sows farrowed estimate to the pork slaughter. Variation in pork slaughter is explained by variation in sows farrowed and the hog/corn price ratio. The latter variable is assumed to proxy the incentive to feed to lighter or heavier slaughter weights.

Despite the absence of a tightly identified framework this model provides a powerful explanation of the historical production (Table 51). Change in production aspects which would make this model particularly vulnerable include: pigs/farrowing, pig losses (mortality), slaughter weights unassociated with hog-feed prices (e.g., different type of hog, longer, taller, etc.). As advances in production systems concentrate on these very aspects the above model will become inadequate unless re-estimated in light of additional observations.

The demand relationships are represented by the price equation given in Table 52. The structural relationships implied by this equation are summarized in Table 60.

Table 51. Pork Production Equation

Dependent Variable	Independent Variables		
	Intercept	$SFS_t + FFS_{t-1}$	HP_{t-1}/CP_{t-1}
Pork Production	244.4 (1184)	1.42 (.094)	141.9 (28.1)

Dependent Variable: Pork production (live wt.) Dec.-Nov., mil. lbs.

Independent Variables:
SFS = Spring farrowing sows, thous. head
FFS = Fall farrowing sows, thous. head
HP = 7 Mkt. Hog and Gilt price, \$/cwt.
CP = Corn price received by farmers, \$/bu.

Estimation Period: 1960 - 1978

Estimator: HILU

R^2 = .966
Rho = .60
(19)
S.E./Mean = 277/19945 = 1%
T.P.E. = 1/17 = 6%

Table 52. Pork Price Equation

Dependent Variable	Independent Variables				
	Intercept	PP/POP	SHS+CBS/POP	TP+BP/POP	LDPCI
7 market barrow and gilt price	-268.5 (84.3)	-.403 (.056)	-.41 (.11)	-.28 (.23)	48.9 (12.1)

Dependent Variable: 7 market barrow and gilt price, $/cwt. deflated

Independent Variables:

PP = Pork production, mil. lbs.
SHS = Steer and heifer slaughter (mil. lbs.)
CBS = Cow and bull slaughter (mil. lbs.)
TP = Turkey production, mil. lbs.
BP = Broiler production, mil. lbs.
LDPCI = Log of per capita disposable income, deflated
POP = U.S. population, mil.

Estimation Period: 1960 - 1978

Estimator: OLS

R^2 = .894
D.W. = 2.54
S.E./Mean = 1.59/21.62 = 7%
T.P.E. = 5/17 = 29%

Poultry

The poultry sector is included in the model to primarily help provide a complete framework for identifying the entire livestock sector to determine feed demand. The annual time frame is inappropriate for poultry because supply adjustment occurs within a period of one year. Therefore, the models presented below for turkeys, broilers and eggs should be interpreted in light of the limitations associated with severe time aggregation.

The poultry sector has been subject to tremendous structural change. Production has become concentrated through market integration. Large automated structures for production have contributed to large increases in labor productivity. Genetic improvements over the estimation period have allowed for substantial gains in feed conversion efficiency. The following table indicates the magnitude of these productivity gains.

Table 53. Changes in Poultry Productivity

Measure of Productivity	Average 1955-59	Average 1974-77
Index of Production Efficiency Output/Hour Labor (1967 = 100)	40.4	178.0 Lbs.
Pounds of feed per:		
Dozen Eggs	5.4	4.3
Pounds live broiler	2.7	2.1
Pounds live turkey	4.2	3.1

The poultry supply model is diagrammed on the following page (Figure 10). Supplies are related to product and feed prices, the previous year's production and a productivity shifter.

Turkeys

Turkey production is influenced by a somewhat longer lag in the decision model. This is associated with the seasonality in egg laying for turkeys. Thus the breeding flock must be carried through a year. This laying flock then determines the number of hatchings and turkeys produced in the following year. The results of this estimation were encouraging despite the a priori concern over the period aggregation (Table 54). The signs of all coefficients were expected and straightforward.

Labor efficiency for broilers was used as a proxy for the entire poultry industry for two reasons. The technology introduced in broiler production is similar for turkey and egg production. This is reflected in the high correlation between the labor efficiency time series for each one of these commodities. The second reason was to help reduce the number of different exogenous variables in the model. As noted above, changes in feed conversion have been significant. These variables are so highly correlated with labor efficiency that to avoid multicollinearity in the model only labor efficiency or feed efficiency was tested. The equation including feed efficiency was a less powerful explanatory model. Nevertheless, all signs and coefficients were as expected and significant.

The demand model for turkeys is represented in the price equation

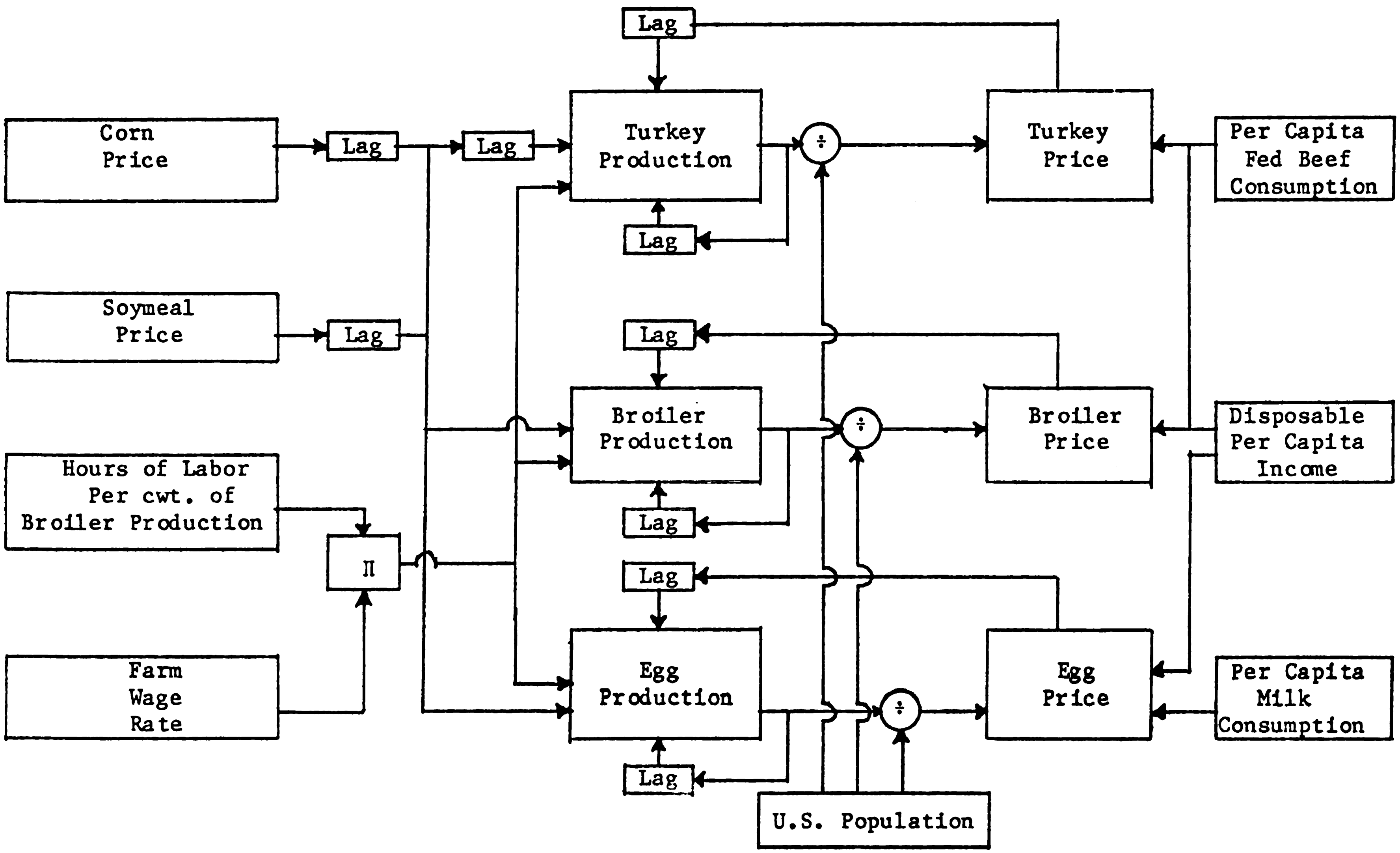

Figure 10. Diagram of Poultry Sector

Table 54. Turkey Supply Equation

Dependent Variable	Intercept	TP_{t-1}	CP_{t-2}	SMP_{t-2}	TR_{t-1}	LH*FWR
	Independent Variables					
Turkey Production	1035.4	-47.8	-141.5	-107.7	.55	-1089.2
	(436)	(10.5)	(60.7)	(27.3)	(.20)	(162.0)

Dependent Variable: Turkey production, ready to cook (RTC), mil. lbs.

Independent Variables:

TP_{t-1} - Turkey price received by farmers, ¢/lb. deflated
CP_{t-2} - Corn price received by farmers, \$/bu. deflated
SMP_{t-2} - Soymeal price received by farmers, \$/cwt. deflated
TR_{t-1} - Turkey production, ready to cook, mil. lbs., lagged one year

LH - Hours of labor per cwt. of broiler production
FWR - Farm wage rate, \$/hr.

Estimation Period: 1956 - 1978

Estimator: OLS

R^2 = .968
D.W. = 1.87
S.E./Mean = 72/1584 = 5%
T.P.E. = 4/22 = 18%

Table 55. Turkey Price Equation

Dependent Variable	Independent Variables				
	Intercept	TPRTC/POP	BPRTC/POP	SHS/POP	DPCI
Turkey Price Received	42.2 (3.5)	-.93 (1.0)	-.83 (.31)	-.46 (.12)	.02 (.004)

Dependent Variable: Turkey price received by farmers, ¢/lbs., deflated

Independent Variables:

TPRTC - Turkey production RTC mil. lbs.
BPRTC - Broiler production RTC mil. lbs.
SHS - Steer and heifer slaughter, dressed wt. mil. lbs.
DPCI - U.S. disposable per capita income
POP - U.S. population, mil. head

Estimation Period: 1954 - 1978

Estimator: OLS

R^2 = .881
D.W. = 1.90
S.E./Mean = 2.1/24 = 9%
T.P.E. = 5/24 = 21%

(Table 55). The level is associated with the level of turkey, broiler and fed beef production. Disposable income is important as well as population which is introduced by putting all explanatory variables on a per capita basis. Every variable has the expected relationship with price. The coefficient for the quantity of turkey however, is not significant. Flexibilities implied by this equation are presented in Table 60.

Broilers

The supply of broilers turns over about four to five times within a year. This allows for considerable flexibility in responding to changing economic conditions. This aspect is not well represented in the annual model presented below. Thus, forecasts should be interpreted with this information in mind. Again the estimated equation (Table 56) appears to explain year-to-year variation very well. A model replacing labor efficiency for feed efficiency was useful but less powerful than the one presented above. The price equation for broilers (Table 57) is specified with the same variables as was the turkey price equation. The results of this equation are very similar to the turkey price equation. Flexibilities are given in Table 60.

Eggs

Production of eggs is the most flexible production system represented in the model. The laying flock matures in two to three months. Liquidation can be influenced by feed prices, egg prices and meat prices. Change in feed efficiency have been less dramatic for egg production than for either broiler or turkey production. However automated handling

Table 56. Broiler Supply Equation

Dependent Variable	Independent Variables					
	Intercept	BP_{t-1}	CP_{t-1}	SMP_{t-1}	$BPRTC_{t-1}$	LH*FWR
Broiler Production	3534.6 (1209)	128.6 (21.3)	-1034.3 (208.7)	-48.7 (35.5)	.73 (.11)	-2657 (639)

Dependent Variable: Broiler production RTC mil. lbs.

Independent Variables:

BP_{t-1} - Broiler price received by farmers, ¢/lb.
CP_{t-1} - Corn price received by farmers
SMP_{t-1} - Soymeal price 44% protein Decatur, \$/cwt.
$BPRTC_{t-1}$ - Broiler production, lagged one year.
LH - Hours of labor per cwt. broiler production
FWR - Farm wage rate \$/hr.

Estimation Period: 1956 - 1978

Estimator: OLS

R^2 = .922
D.W. = 1.54
S.E./Mean = 1.67/16.99 = 10%
T.P.E. = 5/24 = 21%

Table 57. Broiler Price Equation

Dependent Variable	Independent Variables				
	Intercept	BPRTC/POP	TPRTC/POP	SHS/POP	DPCI
Broiler Price Received	32.86 (2.6)	-.92 (.23)	-.89 (.75)	.40 (.09)	.02 (.003)

Dependent Variable: Broiler price received by farmers, ¢/lbs.

Independent Variables:

BPRTC - Broiler production RTC mil. lbs.
TPRTC - Turkey production RTC mil. lbs.
SHS - Steer and heifer slaughter, dressed wt. mil. lbs.
DPCI- U.S. disposable income
POP - U.S. population, mil. head

Estimation Period: 1954 - 1978

Estimator: OLS

R^2 = .922
D.W. = 1.54
S.E./Mean = 1.67/16.99 = 1.54
T.P.E. = 5/24 = 21%

of eggs has been a very important aspect of increasing production efficiency. The egg supply equation is given in Table 58. While the expected relationships were estimated, the coefficients on soymeal price and labor efficiency were not statistically significant. The empirical results reflect that the annual model is weak. Even so more than 70 percent of the year-to-year variation is explained. The demand model identifies the relationship between egg price and egg production, milk production, income and population. Milk and eggs can be either substitutes or complements depending upon the preparation. Therefore, there is really no a priori expected sign for the milk parameter. In addition there has been a noted decline in per capita egg consumption. Various aspects such as the issue of cholesterols in the diet have influenced this. An index of the growing dietary concerns is proxied by time. The equation (Table 59) indicates the dominance of the substitution relationship between milk and eggs. Signs on all other variables are as expected and significant. The flexibilities are summarized in Table 60.

Table 58. Egg Supply Equation

Dependent Variable	Independent Variables					
	Intercept	EPR_{t-1}	CP_{t-1}	SMP_{t-1}	EP_{t-1}	LH*WR
Egg Production	1774.4	14.7	-284.3	-7.93	.68	143.9
	(1175)	(9.5)	(114.2)	(20.4)	(.18)	(157.3)

Dependent Variable: Egg production, mil. dox.

Independent Variables:

EPR_{t-1} - Egg price received by farmers, ¢/doz.

CP_{t-1} - Corn price received by farmers, \$/bu.

SMP_{t-1} - Soymeal price 44% protein, Decatur \$/cwt.

EP_{t-1} - Egg production, lagged one year.

FWR - Farm wage rate, \$/hr.

LH - Hours of labor per cwt. lb. of broiler production

Estimation period: 1964 - 1978

Estimator: OLS

R^2 = .774

D.W. = 2.38

S.E./Mean = 87.7/5571 = 2%

T.P.E. = 5/14 = 36%

Table 59. Egg Price Equation

Dependent Variable	Independent Variables				
	Intercept	EP/POP	MP/POP	DPCI	TL
Egg price	1873.4 (263)	-6.55 (1.1)	-.048 (.03)	.052 (.008)	-419.8 (58.7)

Dependent Variable: Egg price received by farmers, ¢/doz.

Independent Variables: EP - Egg production, mil. doz.
MP - Milk production, mil. lbs.
DPCI - U.S. disposable per capita income
TL - Trend, Log (i) i = 54, ..., 78
POP - U.S. population, mil. head

Estimation Period: 1954 - 1978

Estimator: OLS
R^2 = .889
D.W. = 2.22
S.E./Mean = 2.34/36.7 = 6%
T.P.E. = 5/24 = 21%

Table 60. Flexibilities for Price Dependent Livestock Demand Functions

Dependent Deflated Price	Independent Explanatory Per Capita Quantity									
	Pork	Steer & Heifer	Cows, Bulls & Non-Fed	All Beef	Milk	Broilers	Turkeys	All Poultry	Pork & Poultry	Eggs	Disposable Income
Pork	-1.837			-2.093				-0.623			2.261
Steer		-1.862	-0.606						-0.171		1.826
Cow		-0.998	-0.877								1.488
Milk					-0.790						0.510
Broiler		-1.797				-1.908	-0.404				3.170
Turkey		-1.452				-1.224	-0.300				2.220
Egg					-0.821					-5.097	3.725

CHAPTER IV

The Policy Framework of the Model

The objective of this chapter is to provide a detailed discussion of the policy interface within the model structure. Two composite policy variables, the effective support rate and diversion payment are specified as important influences in the crop supply sector. A description of the conceptual basis for these variables is presented.

Following the measured significance of government programs on crop supply as demonstrated in the previous chapter, a reasonable forecast must reflect expected policy interactions over the forecast period. The hypothesis that commodity policy is endogenous to the supply and demand framework is reasonable.

Pronouncements by the USDA such as the following statement clearly supports this position.

> Feed grain program decisions to be announced this month or next will affect the size of the harvest a year from now and its contribution to the United States stocks for the period 12 to 24 months in the future.
>
> Factors being considered before making the program decisions include projections of domestic livestock inventories and their feed demand during 1978/79 and feed grain projections in major world production and consumption regions and their effects on United States carryover stocks is 5.7 percent of world feed consumption, an amount judged by Administration officials as a fair share of world feed grain stocks to be held by the United States.
>
> <u>Agriculture</u> <u>Outlook</u>, October 1978

Demand management is a concept which is not new to the United States agricultural policy. PL-480 shipments in the 50's and 60's as well as substantial publicly held (CCC) reserves were primary instruments. What is relatively new however is that the 1977 Agricultural Act created an indirect control mechanism, producer-held reserves, the management of which is integrally tied to supply management instruments. Specifically, the "trigger" and "call" mechanism for initiating and requiring liquidation from the reserves are directly tied to the loan rate. To the extent that a farmer must comply with production controls to be eligible for the loan and reserve program, supply and demand management are tied together. Furthermore, considerable discretion and flexibility is provided the Secretary of Agriculture for the management of this program.

The 1977 legislation specifically requires the reserve program to be managed so as to "encourage producers to store wheat and feed grains for extended periods of time in order to promote orderly marketing when wheat or feed grains are in abundant supply."

The problem then is not whether to endogenize policy but rather how to endogenize or model the policy process. Ideally this activity is pursued with the aid of the policy decision-makers themselves. At a minimum the process should be modeled with enough flexibility so that relationships which influence policy parameters can be easily incorporated into the design. At the same time, all parameters should be clearly and unambiguously defined so that respecification by decision-makers or researchers is straightforward. This has been the basic objective in the simple framework developed and presented here.

U.S. Agriculture Policy in the Crop Supply Component

Historically, the United States government has been and continues to be involved in supply control of U.S. agriculture. This involvement is made manifest through price and income supports and direct land diversion payments. Under the current legislative mandate the government has as many as seven policy control parameters by which to impact upon producer crop supply decisions. The modeling work which is represented in the present supply component utilizes these parameters to create two composite policy variables which are explicitly included in the estimated supply response equations. These two variables may be referred to as the effective support rate and the effective diversion payment.

For purposes of policy analysis and forecasting, the construction of the two policy variables is explicitly modeled as well. This is done to allow change in any one of the seven control parameters without altering the others. This is important since it reflects the actual policy process; e.g., loan rates are not necessarily tied to target prices, recommended voluntary diversions are not always equal to the set-aside and national program acreage does not necessarily change by the same magnitude as any of the other parameters. The effective support rate and diversion payment policy variables, originally developed by Houck *et al*, are specified as explanatory variables in the crop planted acreage equations.

The Effective Support Rate

The Effective Support Rate is equal to the loan rate discounted by the factor by which set-asides impose upon program participation plus deficiency payments discounted by the national program allocation factor. This may be stated alternatively: the effective support rate equals the effective loan rate plus the effective deficiency payment.

The Effective Loan Rate

The loan rate concept has been a key element in the United States government agriculture policy for many years. The purpose of the loan rate is to establish a floor price. Nonrecourse loans are made available to the producer who then pledges a specific quantity of the crop as collateral. The amount borrowed against the crop then equals the quantity times the loan rate. Should the producer choose not to redeem the loan, then the USDA's Commodity Credit Corporation (CCC) assumes title of the stored crop as full payment against the loan. The calculation of the effective support rate discounts the loan rate by set-asides, when they are in effect. This approach is used because under a set-aside, producers qualify for the non-recourse loan program only after they comply with the program requirements. This aspect can be demonstrated as follows.

In Figure 11 on the following page the nominal support rate is associated with ob planted acres. A set-aside of ab is associated with a lower rate called the effective support rate. Given the likely impossibility to lower the support rate explicitly; in order to achieve a desired acreage reduction, a quantitative control like set-asides, shifts the supply function to the left from S to S'. Here oa acres are associated with the nominal support rate. In terms of the original supply relationship the support rate is effectively reduced. The effective loan rate equals the nominal loan rate times the percent of base acres allowed to be planted and qualify for supports.

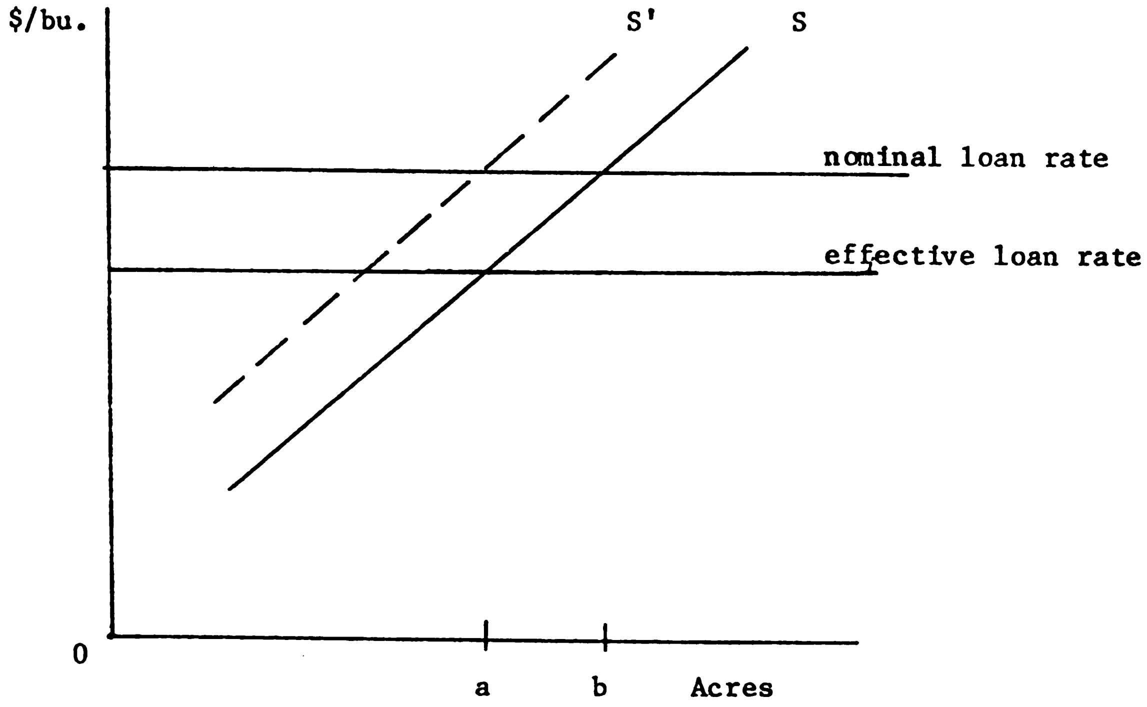

Figure 11. Effect of Set-aside on Acreage Supply and Loan Rate.

The Effective Deficiency Payment

The second component of the effective support rate equation is the concept of an effective deficiency payment. The deficiency payment concept was introduced in the Agrculture and Consumer Protection Act of 1973. The deficiency payment concept relies upon the loan rate, a target price and the average market price received by farmers during the first five months of the marketing year. The loan rate has already been discussed above. The target price, which was a new concept in the 1973 Act, serves the purpose of providing a basis for varying the level of support (deficiency) payments inversely with the market price received by producers. Under the legislated rules no deficiency payments are made if the market price is greater than or equal to the target price.

However if the market price goes below the targer price the deficiency payment equals the difference. The upper limit to the defiency payment then is the difference between the target price and the loan rate. It is this latter measure which is incorporated into the effective deficiency payment. Since we have an expectations model, it would be conceptually more correct to estimate the supply responses against expected deficiency payments, however producers are unable to know with certainty the future market price. They do know with certainty however the level of a full deficiency payment which the USDA announces prior to planting. It is this signal then, which serves as a proxy for the magnitude by which the government intends to support or supplement income to producers.

This full deficiency payment is however discounted by a policy parameter called the program allocation factor (PAF). The PAF is defined by the ratio of National Program Acreage (NPA) to Acres Harvested. The NPA parameter is essentially the national farm allotment. It is established annually by the Secretary of Agriculture at a level which is consistent with the expected domestic and export disappearance with consideration given to a desired carryover stock level. The PAF is used to determine that portion of the crop output which is eligible for payments. The statutory limits on the PAF are 0.8 at the minimum and 1.0 maximum. As an example, if the NPA were set at 63 million acres and 70 million were actually harvested, then the PAF equals 0.9 which in turn means that only 90 percent of the production is eligible for deficiency payments.

The Effective Diversion Payment

The government may utilize two policy instruments to provide incentives to divert land from production. The first is simply a direct diversion payment. A second incentive to divert is tied to a recommended voluntary diversion (RVD) rate, over which the Secretary of Agriculture has discretionary control. If producers voluntarily reduce acreage planted for harvest from the "considered" plantings (i.e., the total of set-aside, haying and grazing and harvested acres in the previous year) in line with the percentage recommended by the Secretary of Agriculture, then the program allocation factor for any such producer will be 1.0. This means that such a producer will receive deficiency payments on 100 percent of the harvested acreage, regardless of the national program allocation factor.

The benefit or incentive to be derived from this is that when the PAF is less than (1.0 - RVD) the producer gets full deficiency payment coverage if the recommended voluntary diversion is met. The net benefit is exactly equal to (1.0 - PAF) times the deficiency payment. A somewhat inexact formulation used as a proxy to measure this incentive to divert is simply the RVD times the deficiency payment. Thus the composite index of government instruments designed to encourage diversion is the effective diversion payment which is equal to the direct diversion payment plus the deficiency payment discounted by the recommended voluntary diversion rate.

Endogenizing United States Agriculture Policy over the Forecast Period.

Unfortunately the actual provisions of the 1977 Food and Agriculture Act were not specified so that support and diversion variables are totally unambiguous for each commodity. Legislated price and income support levels cannot be accepted as certain. Sufficient discretionary authority is provided to the Secretary of Agriculture such that the estimation and forecast of values for the policy variable is not straightforward. For this reason, the policy process has been modeled so that it interacts endogenously with the supply and demand forecasts of the MUS Agriculture Model. This modeling effort does not rely upon the econometric method but rather upon an identification and under standing of the primary linkages between the policy and market forces. Attention has been given to modeling this structure in an explicit manner such that every representation of the hypothesized policy response is understandable and able to be respecified with alternative parameters.

The objective in modeling this component has focused upon the necessity to capture the essence of policy controls such that they are conceptually consistent with the time series data. It is as well important that the framework be capable of reflecting any significant year-to-year changes or responses by program administrators in the substance of program provisions. There are four policy instruments modeled in this component: target prices, loan rates, set asides, national program acreages.

Target Price

This variable is adjusted from year to year by a formula specified in the 1977 Act. For the 1979-81 period this adjustment is specifically required to reflect changes in the moving two year average of variable, machinery and general farm overhead costs. The 1978 figures also included the return to land and management.

The formula is straightforward:

$$\text{Target Price}_{t+1} = \text{Target Price}_t + \frac{\text{Cost}_t + \text{Cost}_{t-1}}{2} - \frac{\text{Cost}_{t-1} + \text{Cost}_{t-2}}{2}$$

Less straightforward is of course the methodology of conceptually and empirically establishing the cost figures. A further complicating aspect is that passage of the Agricultural Emergency Act of 1978 gave the Secretary authority to increase target prices above formula when a set-aside is in effect. This authority was used for example on wheat to increase the target price in 1978 and 1979 to $3.40 up from the formula $3.05 for 1978. Because set-asides are not in effect in the 1980 program the wheat target price must be generated out of the formula and is $3.07.

The primary difficulty in modeling the annual adjustment is that the cost structure is not modeled in this framework. The political realities of recent years have been focused upon setting of target prices, forced something near a parity between the variable costs of production and the target price. Based upon an assumption that the variable cost of production per acre will increase on the average between 8 and 10 percent over the next five year period and further, that yield/acre may be expected to increase by two percent, it appears reasonable to conclude that for the base line, target prices will stay roughly in line with a seven percent increase. This is the base line assumption made for target prices of wheat and corn. Both barley and sorghum target prices are tied to the corn target price at a recent period relationship of 68 percent and 83 percent respectively.

Loan Rates

Under the 1977 Act, the loan rates had no maximum limits with discretion left to the Secretary on increases.

On the downward side however, a maximum lowering of 10 percent per year is permitted if the previous year's market price is no more than 105 percent of the loan rate. The minimum absolute level to which this can be taken is \$1.75/bushel for corn and \$2.00/bushel for wheat.

Of ultimate concern in setting the loan rate is the maintenance of domestic and export markets for the grains, since the loan rate essentially becomes a floor price at which the government directly intervenes in the market. Further concern relates to the possible size of the deficiency payment which is the differential between the target and market prices. An increase in both the loan rate and the deficiency payment, ceterius paribus, results in increases in production and a consequent lowering of the market price and subsequently an increase in the actual deficiency payment and a greater likelihood of the direct government intervention.

For the baseline, loan rates have been tied to the target price respecting recent differentials for each crop. For wheat, the loan rate is approximately 70 percent of the target price, for corn the differential is 90 percent, for sorghum it is 83 percent and for barley it is 63 percent. Since both the forecast period target prices and loan rates are loaded into the model explicitly, imposing any hypothesized levels for either variable is a very simple process. Loan rates for oats and soybeans are linked directly to the corn loan rate.

Set-Asides

An important factor which has been identified in the determination of set-aside policy is the expected level of carryout stocks in the current marketing year. This relationship is modeled explicitly in the policy framework over the forecast period. There are several parameters which are important in specifying this policy response, but the framework is simple and straightforward for ease of alternative specification.

The adjustment process is diagrammed on the following page (Figure 12). Both upper and lower bounds for the estimated variable, ending stocks as a percent of disappearance, are determined. If the estimate is within the acceptable range then no change in set aside policy is made. This reflects the inertia associated with the ability or desire to implement a change in a major agriculture policy instrument.

An additional aspect of this policy instrument is that it tends to be set at discrete intervals. Thus a step function is an appropriate representation. The specific formulations for the baseline reflect 1977-1979 stock disappearance relationships which triggered set-aside programs. A review of the monthly supply and disappearance assessment by the USDA, presented in Agriculture Outlook and the history of program announcements indicates that expected feed grain stocks above 20 percent of disappearance has initiated set-aside action. Similarly anticipated wheat stocks above 50 percent of disappearance has triggered wheat set-asides. The following two graphs depict the baseline response for wheat and corn.

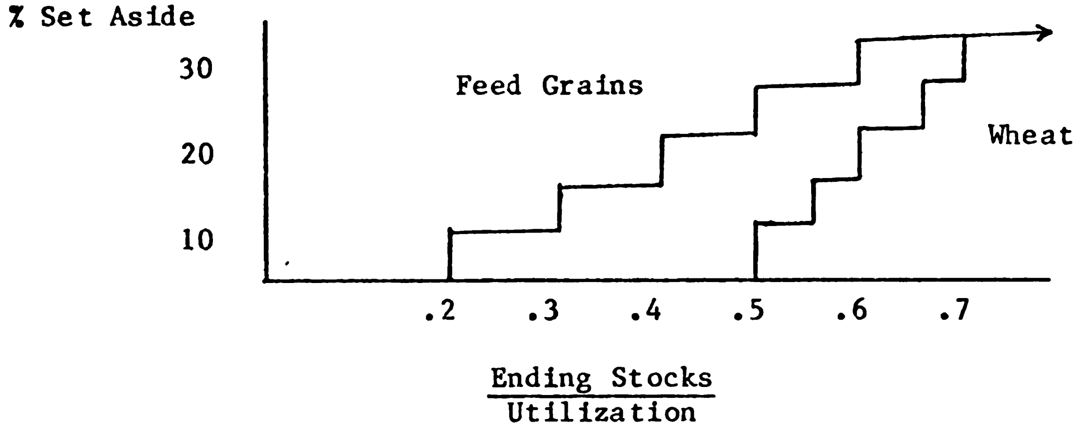

Figure 12. Set Aside Rate Adjustment in Response to the Relationship of Carryout Stocks and Demand

National Program Acreage

The final supply managememt policy variable which is endogenized over the forecast period is the national program acreage (NPA). The determination of the NPA is required to reflect the estimated number of harvested acreage to meet expected utilization (both domestic and export) plus a desired level of carryout stocks. Estimates for three variables are critical, these are crop yield, domestic demand and export demand.

The modeled formulation of this policy determination assumes a constant relationship between desired stocks and utilization. The current year's NPA is then the previous year's NPA plus the adjustment necessary to maintain the stock to utilization relationship.

The baseline specification of this relationship is 18 percent for feed grains and 45 percent for wheat. More explicitly,

$$\text{Wheat NPA}_t = \text{WNPA}_{t-1} + .45 \ * \frac{\Delta \text{ Estimated Utilization}_{t,\ t-1}}{\Delta \text{ Wheat Yields}_{t,\ t-1}}$$

Producer-Held and CCC Stocks Management

Policy interactions on the demand framework of the model are explicitly introduced in the grain stocks demand equations. Specifically the model recognized three holders of stocks: 1) the private trade, 2) producers, through the producer-held reserve and 3) the Commodity Credit Corporation (CCC), through acquisition from price support (non-recourse loan) operations and any other direct purchases. Private grain stocks are determined as the residual of the entire domestic/ international model supply and demand configuration. The producer-held and CCC stocks are specified in the domestic demand framework. The specification of this component of the policy process is a literal expression of the reserve program rules. Unfortunately, while program rules and parameters can be identified, the behavioral content, in terms of producer response, has little history by which to be identified. Thus for the present, the specification of this aspect is synthetic.

While there are distinctly different parameter levels for wheat and feed grains, the structures of both reserves are essentially identical. For this reason, only the specification of the wheat reserve program is discussed here, in detail. Differences between the wheat and feed grain reserve will be noted at the end of this discussion.

The reserve model identifies several important ranges or thresholds for the ratio of wheat price to wheat loan rate. This is a direct reflection of the basic program. Four rules govern this specification.

1) When market price is below the trigger level, producer-held reserve stocks cannot be released. If the reserve is open and the reserves are not at the reserve limit, then the model allows for the reserve program to accumulate reserves as price falls to the loan rate. Furthermore if the reserves are full, and projected total ending stocks are less than 45 percent of the projected utilization, then the reserve limit will be increased to allow for, but not force additional accumulation.

2) Any CCC stocks can re-enter the market at 190 percent of the loan rate. This rate is slightly higher than the call. The gradual liquidation of CCC stocks are modeled so as to avoid shock on price levels.

3) If the wheat price is between the trigger and call levels then stocks will be liquidated in an increasing relationship with price rises.

4) At the call level all stocks are assumed to have reentered the market.

Despite our knowledge of the explicit trigger level, the wheat price information in the model is the season average price. However, the reserve program is managed in terms of monthly price movements. It would be very likely that an estimate of the annual price slightly below the trigger would be associated with some actual triggering through the market year simply on the basis of seasonal patterns. In Figure 13, the monthly price relationships to the season average price are graphed to identify the seasonal pattern of price movements. Depending somewhat upon the sample period used to generate the seasonal pattern, a $3.00 average season price would be associated with a peak monthly price high enough to have triggered the reserve release mechanism at $3.29. In an attempt to incorporate this additional useful information, the nominal trigger level is lowered by factor 0.92 to reflect the likelihood of trigger releases within the year, despite the estimate of the annual price below the nominal trigger level. The entire response accumulation/liquidation of reserves is illustrated in the graph on the following page (Figure 14).

The management of and the farmer response to the reserve program is obviously a far more complex process than this elementary framework suggests. For example, the Secretary of Agriculture is authorized by the reserve legislation created in the 1977 Food and Agriculture Act to have discretion over the following:

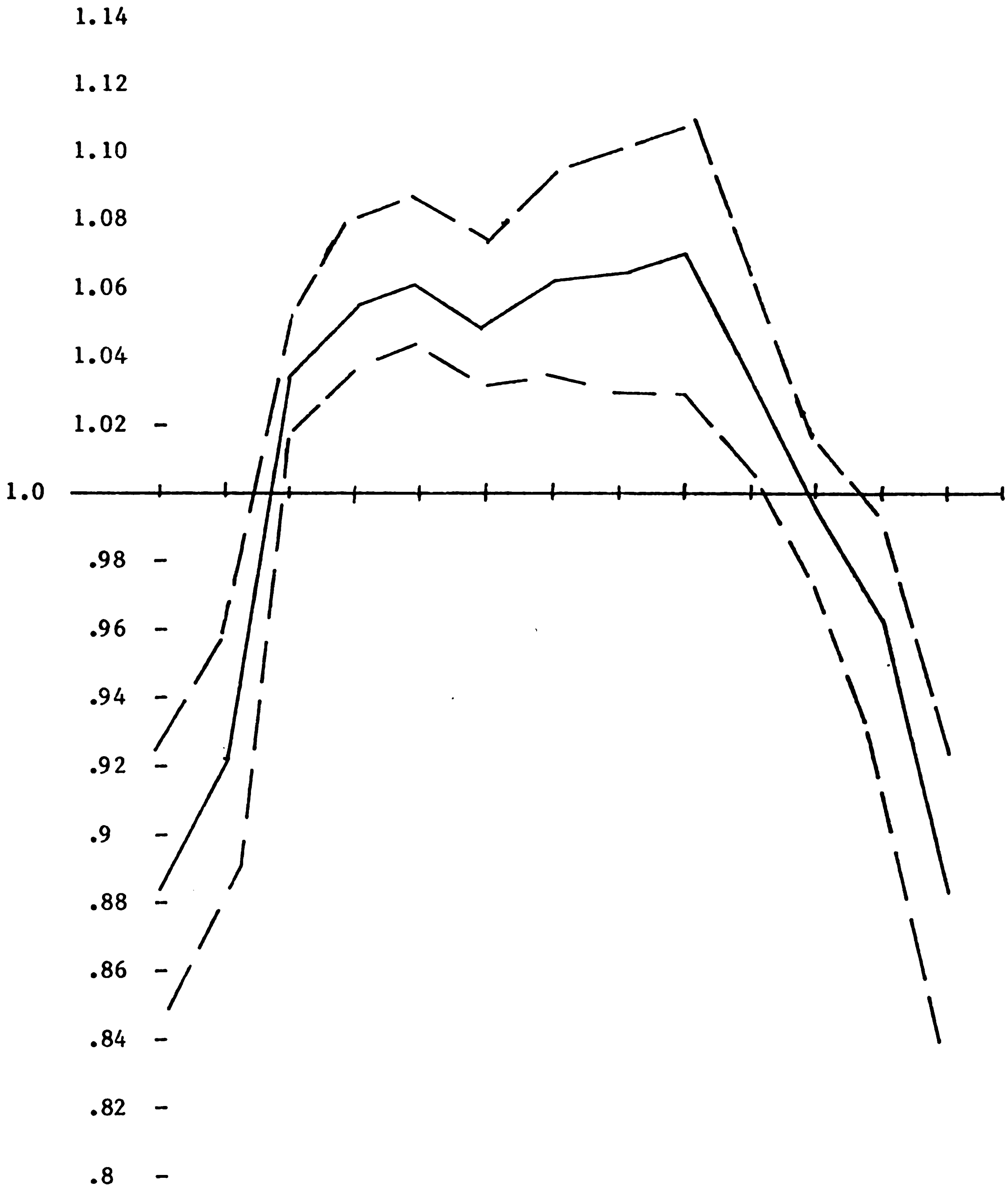

Figure 13. Seasonal Pattern of U.S. Cash Prices Received by Farmers for Wheat (Estimates based on times series 1962-78 regression of monthly prices against crop year annual average price. Dashed lines represent the upper and lower bounds of standard error).

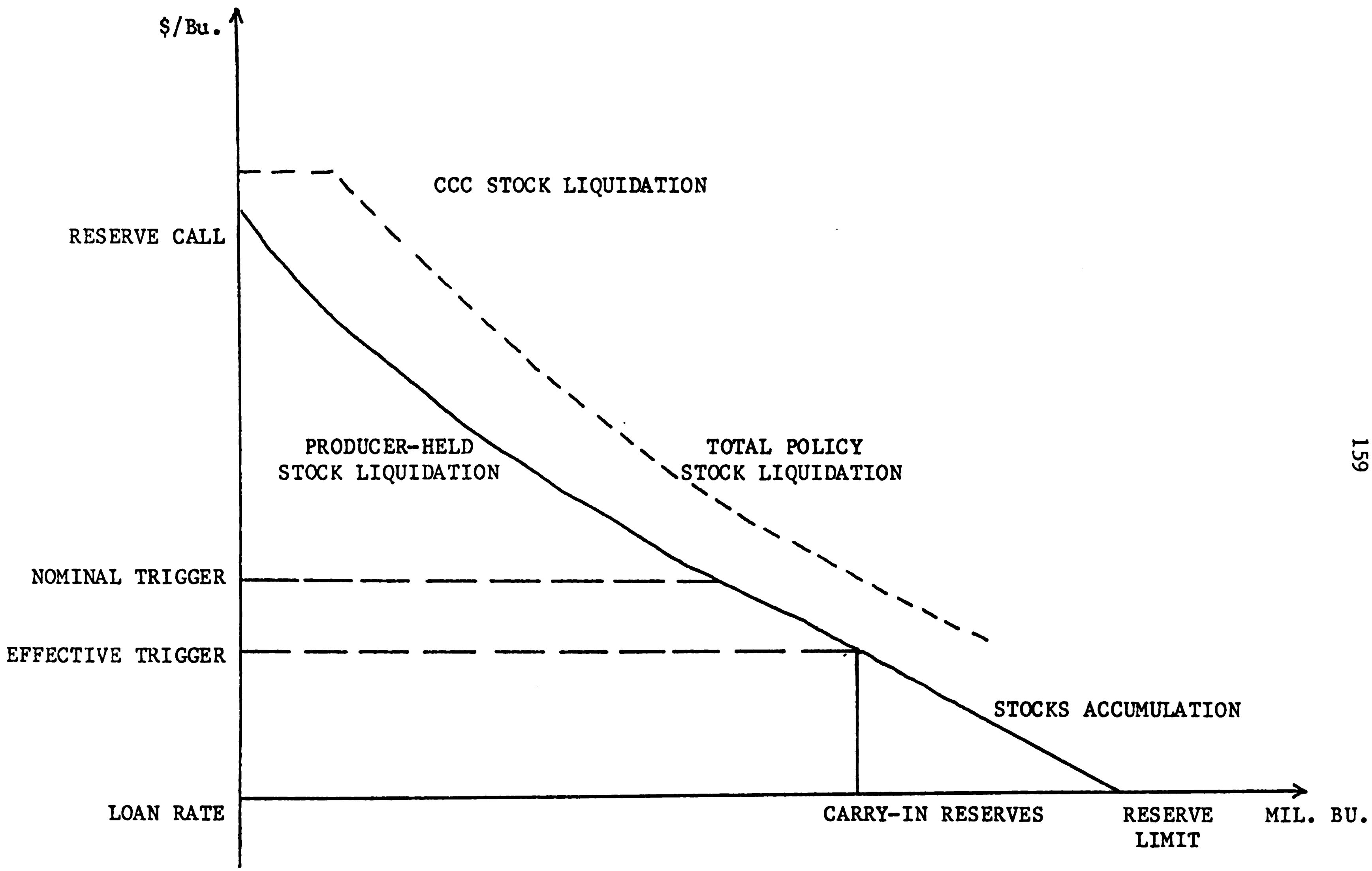

Figure 14. Accumulation/Liquidation Response of Producer-Held and CCC Stocks

1) When the program is open or terminated.

2) Which crops are eligible by year of harvest.

3) The size of the reserves (within a range for wheat).

4) The set of production controls with which compliance is mandatory in order to be eligible for entry into the reserve program.

(5) And finally the substance of several instruments designed to manage participation in the reserves, directly:

(a) storage cost payments;

(b) charge of interest on CCC loans;

(c) a loan facility to lend farmers for new or repaired storage capacity;

(d) ability to extend the storage up to five years;

(e) ability to change the price associated with the release and call level since these are tied to a discretionary rate.

The critical parameters of this component are: 1) the reserve size, 2) the set of incentives to encourage/discourage reserve program participation and 3) the explicit linkage of production controls in terms of compliance/eligibility and the interrelationships. The synthetic response function implicitly assumes that grain is available for reserve program participation and that farmers will accumulate or liquidate stocks in response to relative market price to loan rate changes.

Differences between the wheat and feed grain reserves include the following set of factors:

1) reserve size,

2) loan rates and production controls,

3) interrelationships among loan, trigger and call levels,

4) CCC sales price link to loan rates, and

5) seasonal price deflators.

Both programs are sufficiently generalized so that any of these parameters can be easily changed.

There are many limitations inherent in this simplistic representation. For example, storage capacity (including investment/disinvestment) and availability are not recognized. Thus while additional storage capacity may be available for the country as a whole, it may not be in areas where there are surplus grains or the on farms of producers who complied with the production control programs. Program managers have altered storage cost payments and interest charges to reserve participants in an expressed effort to increase stock levels. Neither of these controls are explicity in the model. These are two of the more important real world aspects which are abstracted from in the model. Recognition of these and other less obvious limitations serve notice that model results are not to be believed so much as they are to be used. Changes in programs if not explicit in the model must be analyzed qualitatively. Interaction between the modeler and the decision-maker is clearly the most reasonable approach in effective application of the model for policy analysis. In the following chapter, a position for the use of quantitative models in general and the MSU Agriculture Model specifically, in policy analysis is presented.

CHAPTER V

The Potential for Policy Analysis

The objective of the discussion in this chapter is to establish the basis for policy analysis based upon the MSU Agriculture Model. At the outset it will be useful to identify a general research position with regards to quantitative models and the potential for contributions to policy analysis. This will be followed by an appraisal of the capabilities and limitations of the MSU Agriculture Model for agricultural policy analysis. This appraisal examines the ex ante forecasting performance of the structural variables and the validity of the policy specification. Finally a discussion of the analysis of the grain reserve program will suggest the potential this model has for contributing to a policy issue of current concern.

Quantitative Models and Policy Analysis

The basic problem for policy analysis is not so much concerned with developing sound programs as it is in providing a framework to evaluate social choices in terms of their feasibility of implementation and understanding of the linkages associated with the program impacts. The primary problem with policy analyses in general, is that the emphasis is overwhelmingly placed upon theoretical refinements and conceptual development. For example, it has been argued that in the case of price stabilization policy analysis, that all too often the empirical research and the decision-makers have overlooked results from theoretical studies (Just). This position would appear to ignore that the theoretical contributions of economists all too often refine concepts which even in a gross form are not credible within the policy process (Hathaway), (1976), Brandow (1977)). The studies on the welfare gains from stabilization are clearly a good example.

The desire for relevance in the policy process is poorly guided by excessive reliance upon theoretical concepts and approaches for which the cost of further refinements exceed the value of the contribution to the problem. Interpersonally valid measures of welfare do not exist in economic analysis. Normative economic information about the impacts of alternative policy rules such as likely supply adjustments from price stabilization can become useful inputs into the political decision process. Through this process normative information becomes validated. However the policy process relies both upon positive and normative information in order to develop decision rules. Johnson (1977, p. 38) argues that "in order to understand fully the acquisition of knowledge by decision-makers and, hence, to be helpful to them in their quest for knowledge, one must be philosophically flexible."

Credibility in this process is not necessarily engendered by claiming to have the method for determining which decision rule maximizes welfare. Rather, analytical models, which are subject to tests of objectivity and capable of reasonably describing the impacts of alternative rules, can provide the decision-maker an interactive framework useful in identifying a choice with an acceptable degree of risk and responsibility-bearing. Decision-makers' ability to bear risks over time depends upon their knowledge of the probability of events about which they have social responsibilities.

Without developing a detailed framework about the determinants of agricultural policy, it is important to recognize that the information system is the basic framework within which any quantitative model interfaces with the decision process. At the base of this framework are the ideas, experiences and problems which lead to theories, hypotheses and possible solutions. Based upon concepts which become operational by observation and measurement, data become available to evaluate and develop analytical frameworks. Out of these models, interpretations and analyses become information to the decision process (Bonnen, 1975). In this regard, it is important to note that economic information is only one type of information necessary and available to the decision-makers. A second important feedback loops which hopefully enables new and changing problems to be analyzed and addressed with appropriate policies.

Information for the decision making process is political currency. The greater the uncertainty, the more valuable the information. Mack (1971, p. 4) states this relationship succinctly. "Uncertainty is the complement of knowledge. It is the gap between what is known and what needs to be known to make correct decisions. Dealing sensibly with uncertainty is not a byway on the road to responsible decisions. It is central to it."

In the most general terms, the role of quantitative models in the policy process is to help the decision-maker in understanding the conditional probabilities of incurring a given social risk. To do this, the model ought to be able to 1) account for complex interactions between real world events, 2) explicity recognizing the policy framework as a component of the model and finally, 3) identify the interactions in terms of meaningful descriptive performance indicators (de Hean, 1978). The identification of the system is critical to usefulness of the model results. Changes in the boundaries of the structure are likely to significantly alter the nature of the model results. Misspecification, omitted but relevant, as well as, included but irrelevant parameters, can be serious handicaps in any analytical framework. The specification of performance indicators requires considerable concern. Weights are given to performance indicators as a matter of course in the process of model design and presentation of analytical results. Therefore, there does not appear to be a useful *a priori* distinction between model techniques which specify unweighted or weighted performance indicators.

The credibility of quantitative models depends upon not only the ability of the framework to explain real world phenomena (which is a precondition for useful forecasting) but perhaps more importantly upon the willingness and ability of the decision-maker to interact. Problems of clarity, uncertainty about the usefulness of such information and the legacies of useless results or interactions with earlier models, can account for low credibility of a model. Johnson suggests several attributes of models and modeling which generate credibility for the contribution to decision-making. Models should make use of relevant ideas and generate relevant information. They should be flexible in philosophic orientation. Optimizing techniques should be used only for appropriate circumstances. Other specialized techniques such as parameter estimations should be used in an economic way. Interaction with both the decision-makers and affected persons is necessary.

The Potential and Limitations of the MSU Agriculture Model for Policy Analysis

The basic attributes of the MSU Agriculture Model include the following:

- a nonoptimizing simulation model
- forecasts of the dynamic time-path of adjustment (3-5 years)
- disaggregated domestic livestock-oilseeds-grains farm level supply and demand
- international trade model for grains and oilseeds
- endogenous U.S. supply and demand policy framework
- aggregated U.S. farm income accounting framework A useful way to

A useful way to examine the model in the context of its ability to account for complex interactions between real world events is to evaluate two recent applications of it to real world events (Quarterly Report).

Early in 1980, the President of the United States imposed an export embargo on grains and oilseeds to be purchased by the U.S.S.R. In an effort to maintain orderly grain and soybean markets, a countervailing package of market supporting policies accompanied the embargo decision. This included the raising of loan rates for wheat and feedgrains, altering the producer-held reserve release and call levels, increasing storage payments on new reserve accumulations, direct purchases and offers to assume contractual obligation of embargoed grains. The model was able to account or reflect the following interactions:

- change in U.S.S.R. import levels,
- change in U.S. export levels,
- potential shifts in other exporting and importing regions,
- short and long term price impacts without the countervailing program,
- short and long term price impacts with the countervailing program,
- changes in loan, trigger and call rates,
- expansion of the producer-held reserves and CCC purchases

- short and long term supply adjustments due to price and policy adjustments for crops (domestic and world) and livestock (U.S.),
- U.S. farm income implication; changes in distribution of crop and livestock earnings, increased cost of government supports.

The model was unable to account or reflect the following interactions.

- longer-run response of importing regions to U.S. as an "unreliable" export supplier,
- longer-run response of other exporting nations to the U.S. as an "unreliable" export supplier,
- implications for general U.S. economy; including balance of payments, intersectoral terms-of-trade, etc.

(this list is not intended to be exhaustive).

A second application of the model has been the identification of the implication of the United States President's intentions for a gasahol program. The model accounts for:

- expansion of program based upon subsidies, market prices, incentives and capacity for expansion and production of gasohol,
- short and long run supply and demand shifts in the feedgrain market, high protein feed market, livestock markets,
- changes in export levels,
- distribution of income between crop and livestock sectors.

The model does not account for:

- substitution between and price effects on all sources of energy,
- total economy implication such as balance of payments, intersectoral terms-of-trade, economic growth, etc.

Based on these two observations, some conclusions about the models limitations can be made. First, all the limitations enumerated in Chapter II associated with aggregation apply to all the endogenous variables. This includes: time, space, product and producer/consumer aggregation. It is likely that from problem to problem, the level of aggregation which is most insightful does not remain constant. The second major limitation is that there is no interaction of the agriculture sector back to the general economy. For policy-makers in agriculture who are supposed to be "team players," this is a serious limitation of the MSU Agriculture Model. The following facts highlight the seriousness of this aspect. Agriculture is a major contributor to balancing our trade deficits. It is the largest U.S. industry; from production to consumption, it employs approximately one-tenth of the United States population. The asset base of agriculture equals three-fourths of the asset base of all non-agricultural industries. The total agriculture sector accounts for 25 percent of the nation's GNP. The same figures are lower if we look strictly at farm level supply and demand but the linkages to the agribusiness sector are so obviously important that this qualification is without merit. Indeed the absence of these farm level linkages to the input supply and product marketing sectors is a very important omission in terms of the model being unable to address a wide variety of domestic policy issues influenced by the agriculture sector's performance.

An aggregate United States farm sector flow-of-funds framework (Baker, 1978) has been added to the model, however, the linkage at this point is only from the supply-demand sector to the financial sector for income accounting purposes. The financial framework is specified with much more information than a simple accounting framework. Aspects which are endogenous to the farm supply-financial linkage such as growth or contraction over time, facilitated by either internal financing or outside borrowing are of considerable importance to monetary policy considerations. This endogenous linkage has not been validated despite the fact that both sectors are fully specified.

The recognition of limitations for analysis of international agriculture policy issues serves to highlight one of the strengths of the model, i.e., that it does in fact have an endogenous international component. However, issues which cannot be easily addressed by this model include many of the aspects of world food and nutrition problems. This is due to the degree of regional aggregation and the omission of rice, the most important food staple in the world.

The greatest potential of the MSU Agriculture Model for policy analysis is with regard to consideration of basic farm commodity policies. This includes traditional policies of price distortion, income support, and farm level supply and demand management. The framework described in the previous chapter allows for explicit identification of many of the primary policy controls available to the United States Department of Agriculture. It is useful to concentrate efforts upon this policy set for several reasons. First, there is a tremendous inertia associated with dismantling these basic programs. Second, the framework as modeled is generalized enough such that a very wide set of alternative policy specifications are possible within the policy framework. Finally, the framework is integrated into a multi-period, multi-commodity, domestic-international model which allows for identification of cross-commodity, short run and long run dynamics, and domestic-international implications. Not all policy questions can be addressed by this model, however, the usability of the model for policy analysis is not necessarily bound by its present specification. As it is part of an on-going modeling and forecasting project, it stands only to improve by evolving under the scrutiny of time and use in policy studies. It is a second generation specification with a substantial debt to the first specification (Trapp, 1976).

An Appraisal of the Model Performance

Two aspects of the model which are important in assessing its' validity include first, how well did it perform in terms of accuracy of endogenous variable tracking over the first three year forecast period and second was the policy framework adequate to capture the interaction between the agriculture sector performance and the policy response. The second aspect is clearly a subset of the first, given the evidence that policy variables are significant in explaining the estimated behavior of the agriculture sector.

An Evaluation of the Ex Ante Multiperiod Simulation Forecasts

The basis of this evaluation is the set of forecasts reported in the MUS Agriculture Model Quarterly Report, Vol. 1, No. 1, Spring 1980.

Verification of a model is always problem dependent, i.e., is it fulfilling its' purpose or objective? Since the model forecast horizon is three to five years the comparison of actual values to the *ex ante* forecasts are based on the most recent three year period, 1980 through 1982.

Ex ante evaluation is the ultimate test of forecast models. This type of evaluation can be facilitated in two ways. One can save the last few historical observations from the model estimation process or alternatively wait for evaluation at a future time. The lapse of time since the completion of the model estimation in 1979 is fortuitous since the estimation process included the observations up to 1979.

Methods of evaluating large simulation models were developed by Theil (1965); more recent contributions by Dhrymes, *et al* (1972) and Sharpiro (1973) provide excellent summaries of the alternative measures.

Four evaluative measures, the two Theil Inequality coefficients and the two types of turning point errors, are used to summarize the model performance. A summary and definitions of these measures for the various commodity sectors are given in Table 61. Rather than present an exhaustive number of alternative summary measures, the actual data and predicted estimates for 32 variables are given in Table 62 with their associated individual evaluative measures.

The first Theil Inequality coefficient, U_1 can take on values between zero and one. A value of zero would represent a perfect forecast while a value of one represents an extremely bad forecast. One may use either level or first differences for the actual and predicted values in the formula, however as Luethold (1975) has indicated the coefficient will take on different values depending upon which method is selected. For accurate comparison to alternative models the method must be similar. The results for the U_1 coefficient presented in Table 61 indicate that in general the level of the forecasts are very close to perfect for the feed grain and dairy sectors and much less perfect for the wheat and poultry sectors.

The second inequality measure provides the only alternative model comparison investigated. The value of U_2 ranges from zero to infinity with again a zero value indicating a perfect forecast and infinity, the worst forecast. The alternative model comparison implicit in this measure is the naive model, i.e., where the forecast is last year's value. A value of one for U_2 is what the naive model would generate, therefore U_2 less than one indicates a superior model to using last year's value and U_2 greater than one indicates a model worse than a naive model. The results given in Table 61 indicate that overall a naive model is superior for the poultry, beef and wheat sector models, and inferior to the feedgrains, corn, soybean, dairy and pork models.

The turning point error measures are defined in Table 61. The wheat, beef and poultry models again perform distinctively poorer than the models for the other sectors.

To examine these summary measures in greater detail, individual variable performance and measures are given in Table 62.

The wheat model results are consistently poor for all equations. The single most significant error is the acres planted forecast for 1981. It is important to note that this result is based upon a synthetic constraint which restricted total crop acreage to 262 million. This constraint clearly ignored the potential for the double cropped acreage which has significantly increased wheat acreage since 1981. Any improvement or decline in the production level forecast accuracy compared to the acreage forecast indicates the validity of assumptions about yields per acre. In all three years the wheat yield assumptions were too low. The domestic use model consistently overestimated demand and in general is slightly worse than a naive forecast model.

Wheat price forecasts had relatively low level error but because actual prices were relatively stable a naive model performed better. Turning point errors of both types were very significant for all variables in the wheat model.

The feed grain component of the model performed most accurately of all components. The possibility of spurious accuracy due to compensating errors by the four different feed grains has not been inves-

Table 61. Model Performance Based on Comparison of Actual and *Ex Ante* Multiperiod Simulated Forecasts, 1980-1982.

	U_1	U_2	T_1	T_2
Wheat	0.21	1.48	2/3	6/7
Corn	0.04	0.64	3/5	1/3
Feed Grains	0.01	0.54	1/6	0/5
Soybeans	0.03	0.71	1/6	1/6
Beef	0.05	2.68	5/7	4/6
Dairy	0.01	1.00	1/1	1/1
Pork	0.04	0.87	0/4	1/5
Poultry	0.08	4.61	6/7	5/6
All	0.07	1.94	19/39	19/39

$$U_1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - A_i)^2} \Bigg/ \left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}P_i^2} + \sqrt{\frac{1}{n}\Sigma A_i^2}\right)$$

$$U_2 = \sqrt{1/n \sum_{i=1}^{n}(P_i - A_i)^2} \Bigg/ \sqrt{1/n \sum_{i=1}^{n}(A_i - A_{i-1})^2}$$

T_1 = ratio of number of turning points incorrectly not predicted to number of actual turning points.

T_2 = ratio of number of turning points incorrectly predicted to number of predicted turning points.

Table 62. Comparison of Actual (A) and *Ex Ante* Multiperiod Simulated Forecasts (P) with Summary Evaluative Measures.

Variable	1980		1981		1982		Theil Inequality Coefficients		Turning Point Error	
	A	P	A	P	A	P	U_1	U_2	T_1	T_2
Wheat										
Acres Planted	80.6	79.5	88.9	75.5	87.3	75.9	.62	1.42	0/1	1/2
Production	2,374	2,189	2,799	2,113	2,809	2,159	.12	1.97	0/0	2/2
Domestic Use	776	843	854	868	875	926	.03	1.05	1/1	1/1
Wheat Price	3.91	3.46	3.65	3.45	3.50	3.55	.08	1.51	1/1	2/2
Corn										
Acres Planted	84.0	82.0	84.2	83.8	81.9	84.1	.01	0.67	1/1	1/1
Production	6,645	7,022	8,202	7,319	8,397	7,484	.05	0.65	0/2	0/2
Price	3.11	2.61	2.50	2.63	2.65	2.71	.06	0.61	2/2	0/0
Feed Grains										
Acres Planted	122.7	120.7	125.0	123.8	123.5	124.0	.01	1.02	1/2	0/1
Production	8,043	8,423	10,069	8,807	10,377	8,984	.01	0.17	0/2	0/2
Domestic Use	6,047	6,161	6,331	6,418	6,453	6,703	.01	0.43	0/2	0/2
Soybeans										
Acres Planted	70.0	71.3	67.8	69.3	72.2	69.2	.01	0.70	1/2	0/1
Production	1,792	2,036	2,000	2,012	2,277	2,045	.04	0.57	0/2	1/3
Domestic Use	1,020	1,060	1,030	1,143	1,130	1,161	.03	0.87	0/2	0/2

Table 62 (Cont'd)

Variable	1980 A	1980 P	1981 A	1981 P	1982 A	1982 P	Theil Inequality Coefficients U_1	Theil Inequality Coefficients U_2	Turning Point Error T_1	Turning Point Error T_2
Beef										
Cow Inventory	37,086	36,900	38,987	38,343	39,319	40,288	.01	0.61	1/1	1/1
Steer & Heifer Slaughter	17,683	18,000	18,231	17,610	17,980	18,368	.01	1.32	1/2	0/1
Cow & Bull Slaughter	3,787	3,385	3,983	3,652	4,377	3,699	.06	1.69	1/1	1/1
Net Beef Inports	2,050	2,089	1.743	1,975	1,931	1,878	.04	0.61	1/2	0/1
Omaha Choice Steer Price	67.05	70.07	63.84	76.51	64.30	80.57	.09	6.30	1/1	1/1
Omaha Commercial Cow Price	44.91	58.17	41.59	63.56	39.56	64.46	.20	5.53	0/0	1/1
Dairy										
Cow Inventory	10,779	10,808	10,860	10,756	11,012	10,710	.01	1.85	0/0	1/1
Milk Production	128,525	127,673	133,013	130,778	135,795	134,372	.01	0.37	0/0	0/0
Milk Price	13.00	12.33	13.80	13.06	13.55	13.58	.02	0.77	1/1	0/0

Table 62 (Cont'd)

Variable	1980		1981		1982		Theil Inequality Coefficients		Turning Point Error	
	A	P	A	P	A	P	U_1	U_2	T_1	T_2
Sows - Spring	7230	7260	6440	7003	5593	6913	.06	1.24	0/1	0/1
Sows - Fall	6829	7008	6258	6688	5810	6809	.05	1.27	0/1	1/2
Pork Slaughter	16432	17129	15716	16040	14123	15925	.04	0.93	0/1	0/1
Hog Price	39.48	37.36	44.05	47.35	55.44	58.80	.03	0.41	0/1	0/1
Poultry										
Egg Production	5806	5632	5800	5498	5765	5353	.03	10.22	1/1	1/1
Egg Price	56.3	43.2	62.3	32.8	58.4	43.9	.21	4.76	0/1	2/3
Chicken Production	12091	12298	12738	11922	12844	11849	.03	1.94	0/0	1/1
Broiler Prices	27.7	22.1	28.5	28.3	26.6	32.4	.08	3.03	2/2	1/1
Turkey Production	2396	2424	2574	2458	2518	2531	.01	0.62	1/1	0/0
Turkey Prices	41.3	45.9	38.4	50.2	37.2	55.4	.15	7.07	2/2	0/0

tigated. However, the forecasts for corn, by far the most significant feed grain, are consistently accurate. Compared to a naive model the forecasts are 30 to 40 percent more correct. This supports the validity of the feed grain component since the corn variables are significant in specification of the other feed grain equations.

The soybean component forecasts are nearly as accurate as the feed grain sector. The soybean supply framework and the domestic demand, to the extent that it is significantly dependent upon livestock production, are validated in comparison to a naive model. Turning point errors are also very low.

The beef component as indicated earlier performed poorly. However relatively encouraging results are indicated for the beef cow inventory equation. The bottoming out of the most recent cycle was missed by one year causing the turning point error. The critique of the beef model offered in Chapter III is supported by the poor tracking for steer and heifer slaughter and cow and bull slaughter and their respective slaughter prices.

The dairy model has near perfect level forecasts. The stability of cow inventory causes the comparison to a naive forecast look relatively poor. The price equation which is an extreme abstraction from the significant policy intervention is quite accurate nevertheless. In terms of supply, the milk yield per cow equation is the single dominant variable. The validity of the production forecasts reflects the importance and accuracy of the milk yield equation.

The pork component is the most accurate of the four livestock sectors. With regard to the sows farrowing equations the errors are primarily in the levels while the dynamics of adjustment are quite clearly captured. This carries over into the hog slaughter and price equations such that no turning point errors were made. Additionally, both equations are significantly superior to the naive model forecasts.

The poorest model not surprisingly is the set of poultry equations. The weakness of an annual specification for the poultry sector has been identified earlier. To the extent that the poultry sector as well as the other livestock sectors in the model have the primary purpose of establishing the domestic demand for the feedgrain and soybeans, it is important that the levels are approximately accurate and that large turning points be captured. In this regard no significant damage has resulted, although a naive model in all equations save for turkey production, would have been substantially more accurate.

The verification of the accuracy of the policy framework specification is the second issue for appraisal. There are two aspects to this. First, did the basic nature of the commodity program change? On the whole the answer to this is no. The loan rate, target price, set-aside, national program acreage, paid diversion, and farmer owned reserve program concepts were all maintained and exercised in the farm commodity program management. The 1980 and 1981 crops still fell under the 1977 legislation while the 1982 crop came under the 1981 farm bill. Several changes in the setting, effect and exercise of these policy instruments were made (Johnson et al 1982, Hargrove 1982).

The mechanism for setting target prices did change. Congress set explicit levels, leaving discretionary authority to the Secretary of Agriculture to raise target prices based on cost of production criteria. The loan rate, national program acreage and set-aside concepts were all retained. Related to the national program acreage is a new concept, base acres, which is used for recommended acreage reduction programs and deficiency payment eligibility. Base acres are equal in general to the actual acreage planted in the previous year. The acreage reduction program is equivalent to set-asides in concept except that it has optional acreage constraints. With the cross-compliance requirement eliminated, substantial slippage is available under a pure set-aside program. Therefore, the acreage reduction program restricts plantings by applying it to base acres of the specific commodity unlike set-asides which apply to current acres of all commodities.

The second more particular aspect for verification of the policy framework is a measure of the accuracy of the policy instrument levels.

Table 63 presents the model values compared to actual for corn and wheat.

The ex ante forecasts of both the loan rates and target prices were extremely accurate. Actual wheat target prices rose slightly less rapidly than forecasted. On the other hand the loan rate forecasts lagged actual values for both corn and wheat.

The case for set-asides and national program acreage is less remarkable. Both of these variables are adjusted by forecasts of production, utilization, and actual and desired ending stocks.

The wheat set-asides forecasted were not exercised by the administration which to be fair in characterization, was captivated by policies of benign neglect. The actual increase in the wheat national program acreage was a response to bring into the program the substantial new acreage. The set-aside behavior for corn is more accurate. The drop in the program acreage was not anticipated by the model. The actual 1982 figures for national program acreage and set-asides are not given due to

Table 63. Comparison of Policy Level Forecasts with Actual Values.

Instrument		Forecast	Actual
Target Prices			
Wheat	1980	3.64	3.63
	1981	3.89	3.81
	1982	4.16	4.05
Corn	1980	2.35	2.35
	1981	2.51	2.40
	1982	2.70	2.70
Loan Rates			
Wheat	1980	2.55	2.50
	1981	2.72	3.00
	1982	2.91	3.20
Corn	1980	2.12	2.25
	1981	2.26	2.40
	1982	2.43	2.55
Set-Asides			
Wheat	1980	10	0
	1981	20	0
	1982	15	15
Corn	1980	0	0
	1981	0	0
	1982	0	10
National Program Acreage			
Wheat	1980	71.5	75.0
	1981	71.5	84.5
	1982	73.5	n.a. *
Corn	1980	86.7	84.1
	1981	87.1	80.5
	1982	86.5	n.a.

Table 63 (Cont'd)

Instrument		Forecast	Actual
Wheat Ending Stocks			
Total	1980	1174	989
	1981	1244	1164
	1982	1203	1541
Farmer Owned and CCC	1980	389 (33)	556 (56)
	1981	387 (31)	649 (56)
	1982	386 (32)	1245 (81)
Feed Grains Ending Stocks			
Total	1980	1714	1034
	1981	1550	2786
	1982	1158	3334
Farmer Owned and CCC	1980	618 (36) **	423 (41)
	1981	377 (24)	1612 (71)
	1982	16 (1)	3925 (88)

* not applicable

** Figures in () equal the percent of farmer owned and CCC stocks to total stocks the subplanting of these concepts by base acreage and the acreage reduction program.

The performance of the farmer-owned reserve and CCC stock levels was extremely poor. While the levels for 1980 are within reason, the 1981 and 1982 levels are unreasonable. Part of the error relates to the error of total ending stocks. However the forecasted composition of ending stocks as indicated by percentage of farmer-owned and CCC stocks to total move in a direction opposite to actual.

Potential for Analysis of Grain Reserves Management

The United States Congress mandated the creation of a grain reserve program in the 1977 Food and Agricultural Act "to promote the orderly marketing of such commodities." The legislation clearly reflected a concern for market stability. It was given explicit design features with built-in management flexibility, as discussed in the previous chapter.

Experience with the program to date has led to a generally favorable assessment and it is suggested that this reserve policy will be maintained and become an active instrument of market control by the government. Ironically, out of the myriad of studies on price stabilization and reserve stock management, very few have addressed the program explicitly (Eaton, 1980). A review of previous research indicates that there has been an overwhelming emphasis upon theoretical welfare refinements and design prescription based upon various optimization techniques. The descriptive simulation technique has been seldom used in the reserve analyses. However, given the existing reserve program, this technique lends itself rather well to the evaluation of the impacts of alternative program management. It is contended that there is a serious vacuum on this type of analysis. Further, the design of the MSU Agriculture Model is clearly capable of facilitating this analysis.

The reserve program rules have been modeled explicitly, thus various aspects of the reserve management can be evaluated. This includes changes in the reserve size, changes in the set of production control linkages, changes in the differential between call and release prices, rule responsiveness to market price changes. All of these aspects have recently been raised as research issues by the USDA. The model is multi-period which allows for describing not only the short-run impact but also longer run responses. For example, will there be unintended production responses as a result of reserve accumulations? Will production controls be consistent and cost efficient with a given set of reserve management rules?

While the framework is descriptive, outcomes subject to constraints can be easily modeled. For example, the reserve limit can be described as that level necessary to maintain prices within a prescribed band. Monte Carlo analysis of a stochastic simulation driven by random draws from empirical yield probability distributions can suggest with what probability any given reserve size would be sufficient to keep price within the band.

The model recognizes exports endogenously. Thus an important but neglected research issue such as what are the implications of price management within the loan-trigger band upon the United States ability to export grains, can be evaluated with the use of the MSU Agriculture Model.

Finally, the model is multicommodity. The significance of the grain price volatility on the cattle sector in the early 70's has been discussed earlier in the study. To what extent will alternative management rules impact upon the livestock sector? To what extent will the reserve program affect the crop mix and substitution? The model has specifically recognized these cross linkages and would be expected to provide useful insights into some of these aspects with obvious distributional implications.

CHAPTER VI

Summary and Conclusions

This dissertation has dealt with the problem of developing an analytical framework capable of contributing to our understanding of the broadening scope and complexity of U.S. agriculture. This industry operates within a turbulent environment, subject to price and income volatility, vulnerable especially to resource constraints and changes in policies of monetary, international trade and geopolitical relations.

The objective was to develop a supply, demand and policy framework of the U. S. domestic grain, oilseed and livestock sectors. The departure of this research from previous U.S. agriculture sector modeling is in the exercise of identifying the integral nature of U.S. agricultural commodity policy within a supply and demand framework. The model is a contribution to a larger ongoing modeling effort, the MSU Agriculture Model.

The model is a multi-commodity, multi-period descriptive non-optimizing simulation framework. The specific objective of the model is to assist in analyzing and projecting the intermediate to long-term effects (three to five annual periods) of the changing environment on the U.S. grain, oilseed and livestock sectors.

The simulation framework is based primarily upon econometrically estimated equations of supply, demand, price and policy relationships. However many relationships identified in the model are not econometrically estimated, but rather based upon knowledge of decision rules and responses, such as government behavior, known biological limits and resource constraints.

The structure of the model is characterized as a set of integrated commodity models with three important sets of linkages: 1) feedgrain-livestock sectors, 2) crop supply, demand and policy management, and 3) domestic-international grain markets. The crop sector is disaggregated into wheat, corn, sorghum, barley, oats, and soybeans. The livestock component has separate sectors for beef, dairy, pork, and poultry. The policy framework identifies both supply and demand management policy interactions. The supply management recognizes the role of loan rates, target prices, set-asides, national program acreage, diversion payments, and recommended voluntary diversion. Demand management identifies the Commodity Credit Corporation stocks and farmer-owned reserve stocks rules and their relationships to the supply control variables. The domestic-international linkage is based upon export supply available from domestic production and domestic grain prices received by farmers which are derived from export prices.

Equation estimates are presented for each major endogenous variable in the domestic component of the model. The crop models are based upon behavioral relationships for acreage supply with yields treated as exogenous. The single equation estimation for acreage supply for each crop yielded very significant statistical explanations. A detailed analysis of the corn acreage supply response revealed the independent and significant relationship with price levels and variability and government commodity programs. The effective price support elasticity of supply was estimated at 0.21 in the short-run and 0.29 in the long-run. These estimates are significantly higher than estimates generated by earlier studies and by the same specification for earlier periods,

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suggesting that corn producers have become more responsive to government programs. A hypothesis that the response to government programs is inversely related to the difference between the market price and the effective support rate was investigated, no support for this hypothesis was generated. The conclusion is that a "forward price," i.e. the support rate, has an independent role as a signal for resource allocation. The effective diversion payment variable also is identified as a significant variable. In terms of relative government expenditure efficiency, the paid diversion is significantly more cost effective than adjustments in the loan rate, target price, and set-aside.

The substitute relationship between soybeans and corn is examined in regard to a relative price level and relative price variability framework. Cross elasticity estimates under variable market conditions indicate significant differences consistent with the irreversible supply relationships implied by the asset fixity hypothesis. The additive effect of absolute level and relative level (variability) of corn to soybean prices, generates significantly higher cross-elasticity estimates than when absolute level is considered alone.

The response of acreage supply to corn prices is less inelastic than estimated for earlier time periods and in earlier studies. An estimate which includes the effect of price variability lowers the elasticity estimate slightly. Unlike the case for soybean cross elasticities estimated under variable market conditions, the own price elasticities are not significantly different.

The feed grain and livestock linkage is based upon the supply of livestock production as a derived demand for feed grains. Feed grain demand is estimated by multiplying the estimated feed grain consumed per grain consuming animal unit by the number of grain consuming animal units, a weighted index of the various livestock production levels in the model. Utilization of wheat for feed is estimated separately since this is a significant source of variability in total domestic wheat utilization. Domestic utilization of wheat for food consumption was based on a standard price and income specification. Seed demand which tightens the explanation for total domestic disappearnce is estimated based on a derived demand associated with expectations for next year's acres planted.

The domestic and international components are importantly linked by export demand equations (which were not included in this study) and the price transmission from export prices to prices received by farmers. The corn and wheat price linkages are estimated and explained as a function of export price level and change, and rail freight rate index. Other feed grain prices were estimated as a function of corn price adjusted by relative production of each respective feed grain to total feed grain production.

The livestock component is structured to generate annual estimates of beef and hog slaughter, milk and poultry production and their respective prices. Inventories of breeding stock except for poultry are estimated and provide the primary driving force of adjustment reflected in the production and price relations.

Several hypotheses were tested in the beef model. Particular attention was given to the nature of the lagged price structure for the cow inventory model. Symmetrical and asymmetrical specifications were examined. The separation of expansionary and contractionary signals revealed significant differences in the response behavior. The implication of this difference is that a symmetrical response specification would underestimate the cow inventory liquidation and overestimate the rate of expansion. An alternative specification for the beef model as estimated was discussed in order to identify its potential weaknesses. The conceptual concern was with the biological constraints which were largely ignored.

The dairy model was based on three estimated relationships, dairy heifer replacement inventory, the cow inventory and milk production per cow. Cow inventory multiplied by the yield estimate generates milk production estimates. The milk price is determined by milk supply and appropriate demand shifters. The important policy interface with dairy was not investigated in this study.

The pork model, structured similarly to the beef and dairy models, is driven by sow farrowing estimates, disaggregated into spring and fall farrowings. An asymmetric supply response provided a significantly more powerful explanation of spring farrowings. However, a symmetric response on fall farrowings could not be rejected. Hog slaughter was based upon an estimated relationship to total annual farrowings lagged six months and the hog-corn price ratio. Hog prices are estimated in terms of supplies of pork, beef, poultry and income levels.

The poultry model consists of annual production and prices for broilers, turkeys and eggs. The annual specification is admittedly unsuitable for describing the adjustment dynamics of the poultry industry. Nevertheless, powerful equations were developed explaining historical annual levels.

The policy framework which endogenizes the farm commodity programs is described in detail. The supply management policies are formulated into two composite variables which are significant in the crop supply models. The farm commodity programs also include demand management in terms of the farmer-owned reserve and CCC stocks management. The parameters, decision rules and behavioral responses to liquidation and accumulation are formulated to generate estimates of the distribution of ending stocks to farmer owned, CCC and free stocks. The model was evaluated in terms of its validity to forecast accurately according to its objective of a three to five year horizon and ability to contribute to our understanding of policies with complex interactions. It is argued that the credibility of large economic models of agriculture in a policy analysis is enhanced if the framework is able to account for complex interactions among real world events. It should also explicitly incorporate the important participants, commodities and policy rules and responses. Some of the model's strengths and weaknesses are identified based upon two early applications of it to the 1980 Russian export embargo and the gasahol program. Model specification and the types of problems to which a model can contribute an understanding are recognized as being interdependent.

The credibility of a model depends in large measure upon its ability to make accurate baseline forecasts. In this regard, a comparison of actual and *ex ante* forecasts of the major model variables is evaluated for the period 1980 through 1982. This type of appraisal is an ultimate test of its accuracy. Four evaluative measures, the Theil inequality coefficients and the two turning point errors were used.

The feed grain, soybean, pork and dairy components performed very well. The wheat, beef and poultry sectors were significantly less accurate.

An appraisal of the policy model specification as it was endogenized over the forecast period was also scrutinized. Loan rates and target prices were accurately tracked. Production control instruments and demand management responses were less accurate. While the policy framework is naive in many respects, the period over which it was tested, to be fair, may be characterized by a significant philosophic shift in the view of government's role in the agriculture sector and the economy in general. Furthermore disturbances associated with the international component which were not accurately forecasted, altered the efficacy of the policy framework performance. Accurate multi-period policy response forecasts are likely to be unreasonable in a deterministic sense. This will be particularly true with a change in either administration or major omnibus farm commodity legislation. A conclusion and recommendation for future study is that the policy framework can be integrated and endogenzied into the U.S. agriculture supply and demand framework. Further study on estimation and explanation of policy response is needed. The uncertainty which dominates the agricultural policy environment necessitates that analyses be couched in probabalistic simulations.

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