ABSTRACT

AN ECONOMETRIC SIMULATION MODEL OF THE
UNITED STATES AGRICULTURAL SECTOR

By

James N. Trapp

The purpose of this dissertation effort is to develop a computerized econometric simulation model capable of assisting in the analysis and projection of intermediate to long-term effects of changing domestic and international market conditions on the grain, livestock and oilseed subsectors of United States agriculture. Within the dissertation is presented a summary of the methodology and procedures used in developing such a model and the subsequent validation and testing of the model.

The modeling activities reported in this dissertation are a part of a current National Agricultural Sector Study at Michigan State University within the Department of Agricultural Economics. The material included in this dissertation is a report upon progress at a point in time approximately two years after the project's initiation. Hence, the modeling results presented here are subject to further development and modification as the project continues.

The model presently consists of three basic components: domestic supply, domestic demand and export demand. These three components are integrated to endogenously estimate prices, quantities

produced, domestic consumption, exports, grain stocks and livestock breeding herd inventories for each commodity. These estimates are made on an annual basis.

The impact of a number of domestic macro-economic and agricultural policy variables on production and markets can be simulated though scenarios of exogenous variables proxying these factors. The impact of various foreign policies and economic factors on the U.S. agriculture sector can also be simulated by means of the domestic-foreign component interface.

The modeling effort focuses on attempting to realistically model:

a) the dynamics of agricultural supply response;

b) the interaction between the feedgrain and livestock subsector;

c) the impact of feedgrain and foodgrain policies on crop production;

d) the interface between U.S. domestic agricultural markets and world markets for agricultural products.

Both geometric and polynomial distributed lag equations are used to estimate supply responses. In addition fixed asset constraints to expansion and contraction of supply are recognized in livestock production by consideration and estimation of breeding herd sizes.

Crop supply responses explicitly recognizes the impact of government policy by use of an "effective support price" variable and an "effective diversion payment" variable. Government and private grain stock models are endogenous to the model and interact with

other components to affect prices and supplies of grain. Major inter-crop competitions for land is recognized through cross policy and cross price expectation elasticities.

Derived demand estimates are made for feedgrain and high protein feed for each category of livestock. Derived demand for feed by each category of livestock is affected by the production level of livestock in that category, the price of the livestock product, own feed price and price or quantity of substitute feeds available.

U.S. exports of grains are determined simultaneously with domestic grain utilization and stocks of grain. U.S. grain exports are a function of U.S. grain prices, competing exporters' grain prices, U.S. grain stock positions, P.L. 480 export levels, and importing nations' population, income and grain production.

The model is capable of realistically simulating historical interactions of the agricultural sector. Tests of one-year prediction accuracy within the sample period produced results as follows: the average absolute error of prediction was 8.68 percent; 81 percent of the variance of the endogenous variables was explained i.e. the average simple correlation coefficient was .81; and 82.4 percent of the turning points were properly predicted.

Observation of the model's dynamic properties reveals that it generates reasonable cyclical patterns in livestock production. Cycles are also generated to a minor extent in crop production. The model also generates stabilizing cyclical adjustment responses to all exogenous shocks tested.

Attempts to use the model to forecast outisde of the model's historical data period resulted in realistic projections if unique exogenous shocks during the post data forecast period (1972-75) were adjusted. However, without adjustment for these unique and historically unprecedented exogenous shocks, the model does not forecast well.

Sensitivity analysis of the model indicates that government policies for food grain of the type that existed in the 1960's are generally capable of quickly stabilizing many types of exogenous shocks to the system. Feedgrain policies on the other hand are not nearly as capable of stabilizing the feedgrain and associated livestock sector under various simulated shocks. This is attributed to the lack of a soybean reserve stock policy and the cyclical, lagged response of livestock production. Estimates of the magnitude as well as the duration of response to various exogenous shocks are presented in the study.

It is felt that the objective of developing a working computerized agricultural sector model capable of assisting in evaluating demand and supply projections under alternative market conditions is fulfilled by the model described in this dissertation. More importantly the model is believed to provide a framework from which to permit subsequent revaluation of projections as more data and information become available. Much has been learned in the process of developing the model and opportunity for continued learning is enhanced by its availability.

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By

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To my father who created and fostered
my interest in agriculture and who also
may be the best applied agricultural
economist I have ever known.

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The National Agricultural Sector Model is no more or less than a collection of empirically expressed concepts. I would like to acknowledge those who assisted in forming and providing concepts to be modeled. They include: Dr. Vernon Sorenson, the author's major professor and co-director of the NASS project; Dr. John Ferris, co-director of the NASS project; Dr. Glenn Johnson; Dr. Susumu Hondai; Dr. John McKeon; Dr. Roy Black, Dr. Stan Thompson and Dr. William Haley.

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CHAPTER I

INTRODUCTION

U.S. agriculture is a highly industrialized system consisting of suppliers of inputs, farmers and several kinds of businesses engaged in buying, processing and distributing farm products. This system is closely interlinked with and affected by developments in the rest of the U.S. economy. The U.S. food system is also of central importance in an increasingly interdependent world agricultural and food economy. This combination of scientific industrialization and increased interdependence along with a great deal of uncertainty leads to the need for improved analytical systems that will help farmers, businessmen and public officials deal with planning and policy decisions. This project is aimed at providing information and analysis for that purpose.

Over the next several years a number of developments throughout the world will influence U.S. agriculture. These include the new trading relationship with Communist countries and the policies they maintain with respect to their domestic food consumption and imports; the extent to which the enlarged European community continues to maintain policies of import substitution; the capacity of highly populated developing countries to maintain food production commensurate with population growth; general rates of economic growth and their effect

on improved diet and increased demand for livestock protein in many middle and higher income countries, and general developments in economic policy, inflation, trade balances and the value of the dollar relative to other currencies.

A second set of conditions that will influence United States agriculture are those that affect the rate of growth in the demand for U.S. food, particularly for livestock products. In recent years beef consumption has grown at a much more rapid pace than anticipated either by economists or by trade interests. Accordingly, the U.S. has become a major importer of beef and beef products. Long-term future demand will be influenced by general growth rates in population and income but could also be strongly influenced by government programs, particularly Federal food programs. Therefore, projection of the strength and rate of growth in demand for U.S. farm products and its commodity composition is crucial to enable estimation of probable future developments in commodity prices, expected rates of growth in output and increased resource requirements.

A third major area of uncertainty about the future centers on issues of supply response, structural change and the reaction of farmers to various economic and policy variables. Shifts in land use along with changes in productivity due to new technology, better management, improved seeds, insecticides, fertilizers, etc. will determine the mix and level of output. With adequate price incentives American farmers have the flexibility to increase output and adjust to market requirements. The conditions under which adjustments will occur, however, will be influenced by the fact that farmers are faced with new uncertainties and increasing costs due to higher prices on fertilizer, labor, land and other inputs.

Considerable uncertainty arises from factors that are external to agriculture, such as developments in petroleum markets and energy policy, inflation and its implications for price and exchange rate stability, etc. The mix of these external factors that affect both domestic and foreign demand and prices of inputs and outputs add a great deal of complexity to the process of assembling information for decision making.

Objectives

The nature of the problems faced by United States farmers, businessmen and public officials indicate an obvious need for a more thorough information and analytical base from which emanate planning and policy decisions. In response to this need a team of researchers was formed at Michigan State University to conduct a national agricultural sector study and develop an analytical and information generating model of United States agriculture.

This study and the associated modeling effort has the broad purpose of analyzing and projecting the intermediate to long-term effects of changing domestic and international market conditions on the grain, livestock and oilseed subsectors of United States agriculture. Specifically the study seeks to accomplish the following objectives:

1) To make projections of:

    a) probable developments of export demand for U.S. agricultural commodities.

b) probable levels of domestic demand for U.S. agricultural commodities.

c) the most likely output mix and growth patterns of U.S. agricultural production.

2) To aggregate supply/demand projections and develop estimates of their implications relative to gross farm revenue and resource requirements.

3) To analyze the affect of feedgrain, foodgrain and export policies upon U.S. agricultural markets.

4) To analyze the effect of macro economic factors including U.S. and foreign incomes, populations and inflation rates upon agricultural markets.

5) To develop a computerized analytical model of the U.S. agricultural feedgrain-livestock sector which will:

   a) make base line projections of the type desired in objective one.

   b) provide an analytical capacity capable of generating information relevant to objectives three and four.

   c) provide an organized and documented base of information and concepts which can be added to and updated over time with improved information and analytical capacity.

This dissertation deals specifically with objective five, including the role of an analytical and information generating model in assisting in the fulfillment of objectives one through four.

The types of information the model can provide when coupled with judgement are outlined in objectives one through four. Specifically the model is capable of making projections of the production, forms of utilization and prices of 14 major agricultural commodities. In order to make these projections human elements or other models must provide information about such exogenous factors as weather, fertilizer prices, government price support policies, technological changes, domestic income and population levels, interest rates, wage rates, inflation rates, foreign exchange rages, foreign income and population levels and foreign foodgrain and feedgrain production levels. (See Appendix B for a specific listing of variables used to proxy these exogenous factors.)

Analysis of the effect of the above listed exogenous factor on endogenous variables of the model can be conducted. The model also provides a basic structure which can be readily modified to analyze and provide information about the influence of many other exogenous factors on the endogenous variables modeled.

In its present form the model is felt to provide relevant economic information to the following groups of policy and business decision problem areas and teaching activities.

1) Farm management planning and decision problems (particularly in the area of intermediate to long-run investment and enterprise combination decisions).
2) Agribusiness planning and decision problems (again, particularly in the area of plant size and production line decisions).

3) Financial institutions (with regard to determining the probable payback ability of loans and investments in select agriculture production activities).

4) Policy analysis (specifically the analysis of domestic food and feedgrain policy, export controls, exchange rates, government stock policy and U.S.-Soviet trade relations).

5) University and extension teaching (the model is capable of demonstrating in a teaching mode the structural relations and linkages between various components of the agricultural sector and between the general domestic economy, world economy and U.S. agricultural economy).

Dissertation Organization

Chapter II reviews the process by which the NASS model evolved, discusses modeling methodologies and presents a brief review of selected literature. Appendix A contains a list of references describing previous commodity studies that were found useful in specifying the NASS model. Lastly, Chapter II discusses the sources used in obtaining data for the study and the problems encountered in obtaining and using the data.

Chapter III deals in detail with the model's structure and with the methodology and theory used in specifying the model and in estimating parameters. In addition the form of the model is discussed including its design, solution technique, output capabilities and model management features.

Chapter IV summarizes the parameter estimates developed for the model. More detailed discussion and presentation of estimated functional relation used in the model are contained in Appendices C-1 through C-6.

Chapter V evaluates a number of model properties including historical tracking, stability, sensitivity and projection capabilities. The effects created on the output of the model by invoking various "model management features" are also illustrated.

Chapter VI presents the results of several analyses dealing with simulated impacts of policies and events in the U.S. agricultural sector.

Chapter VII appraises the model's current strengths and weaknesses in regard to capabilities, accuracy, potential improvements and its ability to fulfill the initial objectives of the National Agricultural Sector Study. Possible future efforts and objectives of the National Agricultural Study are also outlined in relation to the current status and capabilities of the model.

CHAPTER II

DEVELOPMENT OF THE MODEL

The initial phase of the NASS project involved a process of review and familiarization with previous modeling efforts, methodologies and modeling concepts. From this process evolved the modeling approach used. The approach which evolved is influenced by the purpose of the NASS project, previous modeling efforts observed and the training possessed by the researchers and clientele interests involved in the project. This chapter will discuss the process through which these influences were integrated into the modeling format developed.

The State of Modeling

Man has attempted to make forecasts of the future and projections of the consequences of his actions as long as he has had problems and uncertainties to deal with.[1] Planning, budgeting, decision making, etc. require consideration of the future consequences of actions. Through time, methods and techniques have evolved to assist in making projections and forecasts relevant to solving their problems. Economists and Agricultural Economists in particular have

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[1] A forecast is defined as one's best estimate of "what will happen." A projection is defined as an estimate of what will likely happen if certain conditions are realized. Hence, forecasting is viewed as a special case of projecting where the conditions specified are those felt most likely to actually occur.

assisted in developing some of these methods and techniques but are by no means the only disciplinarians who have dealt with the development of forecast and projection techniques. Statisticians, psychologists, engineers, etc. have all developed methods to make forecasts and projections.

Underlying all forecast and projection methods is the existence of a "system" -- a set of interconnected physical and behavioral relations organized toward accomplishing a goal or set of goals. The art and/or science of projecting involves understanding the system being dealt with so well that one is able to determine what results will flow from the system under certain conditions.

Economics has traditionally attempted to describe behavior in the context of supply and demand analysis and market structure (perfectly competitive, oligopoly, monopoly, etc.) and has taken the overriding goal of decision units in the system to be profit and/or utility maximization. This point of reference has led to the development of a body of theory and understanding of "economic problems" and man's behavior within the "economic system."

Attempts have been made to validate economic theory as developed in the supply-demand-maximization context. Statistical inference methods which test the validity of generalized statements about a population based upon sample observations of the population are often used in this validation process. Econometricians, using statistical inference techniques, have developed empirical modeling techniques with which to build econometric models of economic activities. Over the last two decades nearly every agricultural commodity or commodity group has been the subject of one or more econometric analyses. In general, these analyses have had the objectives of understanding behavior, providing better predictions and forecasts, and improving policy makers' and producers' ability to solve problems requiring economic information.

Many of these studies have focussed on single commodity systems and have ignored broader system interaction and linkage questions. In using these studies to make forecasts, the forecaster was left the task of formulating estimates for many exogenous factors outside the framework of the econometric analysis. This is a particularly difficult task if the exogenous factors of the study have strong feedback linkages to the values being forecast. For example, supply models where production is a function of price are of little use in forecasting without a method of explaining the dynamic interaction between price and supply. Stated alternatively, most past modeling efforts formalize the supply and demand equilibrium for a single product but include only limited information to link this partial equilibrium to the total system. The forecaster must provide the linkage between the partial equilibrium system and the total system if he is to make meaningful forecasts.

No econometric model can perfectly represent a system or subset of a system. Problems of linkages to non-modeled factors will always remain and have to be subjectively dealt with by the forecaster. Computerized modeling techniques recently developed have increased capacity to develop broader, more complex models. However, knowledge and modeling techniques for interfacing components of a

broad system and for defining and understanding the nature of a broad system appear less well developed and applied than individual commodity modeling.

Modelers have met with a number of problems in their efforts to evolve effective techniques for generating forecasts and projections. First, the logic and reasoning needed to make forecasts is often so complex and subjective that they are difficult to describe with empirical tools. This is partly a function of a lack of sophisticated empirical tools and techniques, but perhaps more, a function of man's own inability to actually describe how he thinks and to set these thoughts down in quantified terms. This is reflected in Bonnen's discussion of data that actually represent concepts[1]. Our ability to represent a mental concept as data, even the simplest of concepts, is imprecise. Further, some concepts used in making forecasts are so vaguely defined as to be nearly unquantifiable.

Modeling as a forecasting technique suffers from a problem common to other forecasting techniques. A clear understanding of the system does not always exist. The economic system is complex, ever changing and filled with uncertainty. Knowledge about the economic system is always incomplete but must be understood with enough insight and depth to allow quantification before empirical modeling can proceed.

The previous discussion suggests that empirical modeling has not been and never will be a complete basis for forecasting and

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[1]James T. Bonnen, "Improving Information on Agriculture and Rural Life," American Journal of Agricultural Economics, 57 (December, 1975), pp. 753-63.

projecting crucial economic information. Rather, modeling can serve as a tool for learning, forcing rigorous examination and testing of mental concepts and theories.

Modeling Methodologies

In the NASS project the "system approach" has been taken to analyze and "econometrically model" the "United States Agricultural Subsector." The terms "systems approach," "agricultural subsector," and "econometric modeling" are rather loosely defined and widely used terms and warrant further definition and discussion in the context of their use here.

Systems Methodology

The systems approach is defined by Manetsch and Park[1] as:

> ...a problem solving methodology which begins with a tentatively identified set of needs and has as its results an operating system for efficiently satisfying a, perhaps, redefined set of needs which are acceptable or "good" in the light of trade-offs among needs and the resource limitations that are accepted as constraints in the given setting. There are two prominent attributes of this approach: 1) it overtly seeks to include all factors which are important in arriving at a "good" solution to the given problem and 2) it makes use of quantitative models to assist in making rational decisions at many levels where it is appropriate to use such tools.

The generalized systems approach is intended to be flexible with respect to kinds of information and techniques used. The mechanical and logical nature of the systems approach allows it to

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[1]Thomas J. Manetsch and Gerald L. Parks, Systems Analysis and Simulation with Applications to Economic and Social Systems, Part I (East Lansing, Michigan: Department of Electrical Engineering and Systems Science, 1975), pp. 2-3.

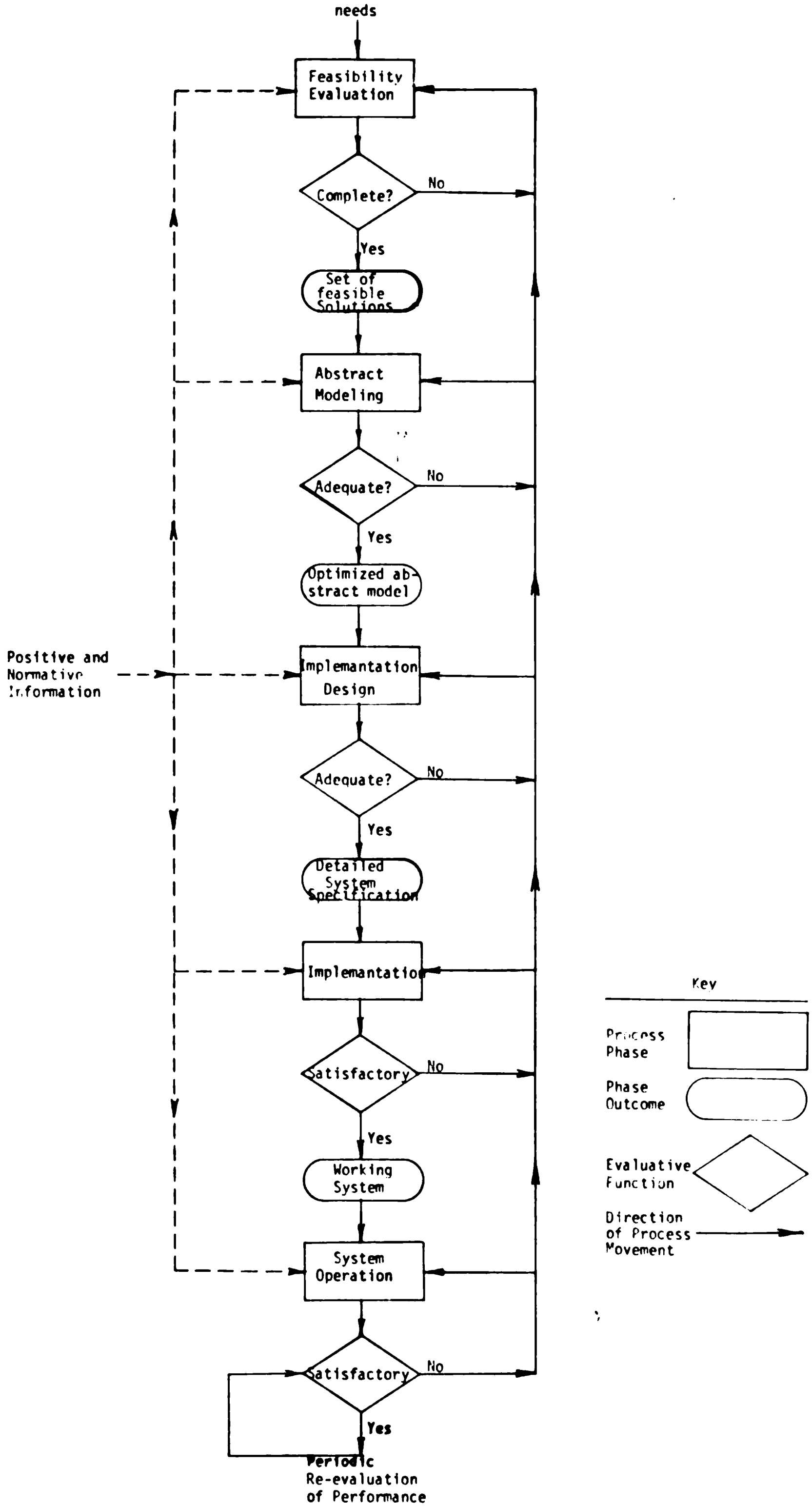
be adopted to a wide variety of uses including projection, optimization, system control and problem identification.

The "systems approach" to problem solving can be envisaged as an iterative process as depicted in Figure 1. Following each phase is an evaluation of new information obtained. If inconsistencies between new and previous information are found, then repetition of earlier phases is called for.

The systems approach begins with a feasibility study consisting of the following steps: 1) needs analysis, 2) system identification (in a general sense), 3) problem formulation, 4) generation of systems' concepts (a broad general list), 5) determination of physical, social, and political feasibility, 6) determination of economic feasibility, and 7) generation of a subset of viable concepts.

Guidelines established for system identification were useful in classifying relevant endogenous and exogenous variables and in defining the proper scope of the model. The use of these guidelines is discussed in Chapter III.

The next three phases of the systems approach, abstract modeling, implementation design and implementation deal essentially with modeling the system and involve the following major steps: 1) Concept selection (selected from those generated by the feasibility study), 2) modeling of these concepts, 3) parameter estimation or approximation, 4) stability analysis, and 5) sensitivity analysis. This dissertation does not proceed to the last step of the systems approach where the model is actually used in a problem solving activity.



Source: Thomas Manetsch and Gerald Park, <u>System Analysis and Simulation With Application to Economic and Social Systems</u>, (East Lansing, Michigan, Dept. of Electrical Engineering and Systems Science, 1975), p. 39.

Figure II.1. The systems approach as a problem solving methodology

Systems techniques were found useful in transferring concepts of the "real world" into a "mathematical model" through representation of a mathematical model in the form of a block diagram. A block diagram allows lines and direction of causation to be shown, feedback loops to be displayed and stock and flow variables to be represented. A properly constructed block diagram graphically displays the simulation components which appear as differential equations or transfer functions in a mathematical model.

In practice, the mathematical model represented by a block diagram is seldom used, but the conceptualization process, organizational structure and modeling techniques inferred from such mathematical models and the theory applicable to them provide useful insight. The ability to develop generalized abstract models from rigorous mathematical model specifications lies at the heart of systems modeling technique. Hence, the systems modeling approach flows from real world concepts to mathematical models or in most applied cases representations of mathematical models to an abstract empirical model designed to simulate the original concept of the real world.

The empirical simulation model requires parameters in order to be implemented. The nature of these parameters is suggested by the mathematical model. The systems approach is not technique specific with regard to obtaining parameters. Regression analysis is one of several techniques which could be used to obtain parameters. Econometric modeling restricts its techniques for obtaining parameters to regression analysis. Since the generalized systems approach does not preclude the use of methods other than regression analysis to obtain parameters it also does not restrict model structure to those entirely amenable to econometric estimation techniques.

The remaining steps of the systems approach involve evaluation of the model and operation of the model. The experiences of systems scientists in computerizing and testing computerized models or simulation models in general were found useful and will be alluded to in more detail at later points in this dissertation.

Subsector Analysis

Shaffer defines, discusses and contrasts "agricultural subsector analysis" to other methodological approaches in the May 1973 issue of American Journal of Agricultural Economics.[1] His statements are as follows:

> ...The uniqueness of subsector studies is not in the methodology or approach but in the scope and comprehensiveness of the research. The area of research is simply defined to include both the vertical and horizontal relationships in a significant part of the food and fiber sector. It is more of a departure in research organization than a departure from traditional approaches of agricultural economic research.
>
> Nevertheless, I would hope that changes in emphasis and approach would be associated with the specific subsector studies. I would hope for a shift from the organization concept of static allocative efficiency to the concepts of dynamic systems and performance. The changing relationships of technology, preferences and institutions, which are often assumed as given in analysis of allocative efficiency, should be explicitly included in analysis of the subsectors... Emphasis on physical transformations and commodities need to be expanded to include institutional, organizational and human behavior dimensions... I would expect that subsector studies would be undertaken with the objective of improving the performance of the subsector, if through no other means than providing participates with an improved understanding of the system in which they operate.

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[1] James D. Shaffer, "On the Concept of Subsector Studies," American Journal of Agricultural Economics 55 (May, 1973), p. 333.

Shaffer also states that he perceives subsector studies to be closely tied to systems orientation.

> Closely tied to my perception of subsector studies is what I would call a systems orientation. By this I mean analysis of an economic activity in the context of a broader system. Such analysis would take into account feedback, sequences and externalities. It includes the idea of simulation in the sense of projecting the flow of consequences from the dynamics of ongoing processes from potential modification in the subsector. Orientation is toward understanding the interdependencies and the effects which are not immediate or obvious. This is, of course, what economists have always been about.

Econometrics Modeling Methodology

Econometric methodology has developed from the use of "statistical inference" procedures to perform tests on economic generalizations or theory. As such econometric modeling procedures emphasize that model specifications should be well supported by economic theory. Model parameter estimation is likened to forming specific generalizations about a "population" and hence should be obtained and tested by using statistical inference techniques on samples of data describing the population for which generalizations are made. This leads the econometric approach to modeling to be largely based upon time series data and various forms of regression analysis. A basic assumption of the econometric modeling approach is that relations and parameters estimated from time series data can adequately describe the relations to be modeled.

Methodological Influences in Relation to NASS

The NASS project is influenced by all three of the previously discussed methodologies and/or concepts. The NASS modeling approach adopts the general nature of the systems approach, and uses systems methodology related to model identification, abstract model design, computerization techniques and validation procedures. However, the NASS model primarily uses econometric estimation techniques and draws upon the body of theory and validation procedures established in econometrics literature. Some compromise of econometric methodology was permitted since econometric estimation techniques were not always strictly adhered to and the solution algorithms eventually used in historical tracking and in making forecast impose various constraints and adjustment processes which are non-econometric in nature.

The NASS modeling effort and project does not focus on normative analysis of the performance of the system as Shaffer would encourage subsector studies to do but shares with the subsector concept the fact that its major uniqueness lies in its scope and concern for making analysis of economic phenomena in a sector wide scope. As is the case with both subsector analysis and systems modeling, the NASS project is concerned with the flow of consequences from the dynamics of the system. Although the model is concerned with human behavior and institutional impacts and attempts to describe their influence on markets, in general such factors are considered to be exogenous to the system. (This does not necessarily imply that such factors are assumed constant.)

The blending of these three methodologies and their associated techniques is felt to have arisen out of the author's training, the nature of the personnel involved in the National Agricultural Sector Study, the purpose of the model and the potential model users or model

clientele. These last two influences, purpose and clientele groups, deserve further discussion in reference to their influence on modeling methodological considerations and development of the NASS project.

As stated in the introductory chapter, a primary objective of the NASS model is to serve as a disciplinary analytical and information generating tool that assists in making forecasts and projections. A second objective is to provide an analytical capacity to assist in analyzing policy and the effects of exogenous disturbances on the agricultural sector. This second objective is closely related to the first. Knowledge of the theoretical and physical relations underlying the system is desired in order to give the forecast credibility and to provide a capability of interpreting the forecast with a deeper understanding and consideration.

A truly "structural" model supported by a well developed set of theory and physical laws may be capable of obtaining credibility solely on the grounds of its structural correctness. The model developed here does not have this capability. The model is structural in nature but is an "abstract approximation of the true structure." As such it contains generalizations, aggregated relations and proxies of unmeasurable factors. Parameters of an abstract model of this type often become nebulous in terms of theoretical and physical validation of their sign and magnitude.

The theory and statistical test of inference as developed by econometricians are often helpful in lending credibility to individual parameter values. However, for the purposes of forecasting, total model performance evaluation and validation, broader tests of

objectivity are often sought. In this respect the following general tests of objectivity are offered:[2]

1) Consistency with observed and possibly recorded experience.

2) Logical internal consistency of the concepts used.

3) Interpersonal transmissibility of the concepts used and the results produced.

4) Workability of the model in the solution of problems.

In reference to these tests, econometric tests of significance can be viewed as a special test of consistency with recorded experience. (Test No. 1.) The theory supporting the econometric specification is a source of concepts found to be logically and internally consistent. (Test No. 2.) The use of econometrics also forces the use of concepts and procedures which have become familiar to a large number of people and hence, assist in filling test No. 3 in that others readily can grasp the concepts and results because of their standardized forms (Chapter V will continue this discussion of validation).

Acceptance and use of a model are clientele related actions. Unless the modeler is the only client, the model will have to pass the test of objectivity held by others to obtain any use. The structuring of the model and the techniques used in the model affect

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[2] These objectivity tests and their use as a verification and validation procedure are discussed in the following two references: G.L. Johnson, et al., Korean Agricultural Sector Analysis, Michigan State University, Department of Agricultural Economics, pp. 43-45. G.L. Johnson and C. Leroy Quance, The Overproduction Trap in U.S. Agriculture, Baltimore, The Johns Hopkins Press, 1972, pp. 44-48.

the specific tests of objectivity it can satisfy. Hence, the modeler must know the clientele's problems, concepts, experiences, etc. and design the model to pass the objectivity tests the clientele demands. Close communication between the modeler and clientele will aid in creating acceptable tests (and a model capable of meeting these tests). Mutual development and understanding of the objectives, structuring and techniques of the modeling process will assist greatly in the creation of a model credible to both clientele and modeler, and hence, a model that will be used.

Data Base

The data base for the model consists of time series data ranging from 1972 as far back as 1945. Data series for the model were chosen with two primary considerations in mind; one being that the data series adequately describe the concept or relation to be modeled and the other being that of accessibility in the future. The second consideration is made so that continued updating of the data series and model parameters can be done easily by a wide variety of potential users. Because of the second consideration, much of the domestic data collected is published in government documents while most of the international data is published either by the United States government or organizations such as the United Nations or the Food and Agricultural Organization.

The preceding considerations for collecting data led to some conflicts. The most conceptually accurate data is often available only from obscure sources and means of derivation. Secondly, many of the published sources of data used suffer from rather long time lags between events and publication. This is illustrated by the fact that at the time data was collected for this project in the fall of 1974, a comprehensive set of data was available for no later than 1972.

A primary problem in collecting data for a model which deals with diverse production activities and many countries is to obtain a set of data which is consistent in definition with respect to time, place and form features. For example, the category of wheat imports or feedgrain imports in international trade data includes grains of different quality and variety than United States classifications of wheat and feedgrains. Also, annual prices in world trade data are calculated implicitly by dividing total value of imports by total quantity and therefore are unweighted averages for calendar year periods. United States prices received by farmers for various crops, on the other hand, are monthly weighted average crop year prices.

Often data series such as those just described must be related to each other. The definitional as well as the economically caused differences will be reflected in the parameter estimates. There is little problem if the definitional differences are constant. The parameters can either be interpreted with the definitional difference considered or data transformations can be made removing the definitional difference, when the difference is known precisely enough to quantify. However, in the case where the definitional differences are not constant and are actually to some extent changing in response to economic forces, bias is created in the parameter estimates. In some cases there are modeling adjustments to try and

remove definitional discrepancies and in others the magnitude of discrepancy is felt to be small enough to be ignored. Such adjustments, the source of the data and a description of the data are given in Appendix B for each domestic data series used in the model.

CHAPTER III

METHODOLOGY

This chapter presents a descriptive overview of the NASS model. Following this overview a discussion of methodological guidelines for determining the scope of the model and the application of these guidelines is discussed. This discussion is followed by a presentation of the theory underlying each general type of functional relation specified in the model. In the process of developing the theory underlying each general specification, the assumptions made and their effects on model specification and capabilities are discussed. Lastly, this chapter contains a section describing the approach used in computerizing the model. This section also alludes to some of the various options and model management features being developed for use with the model.

Model Overview

The NASS model consists of three basic components:

1) Domestic Supply Component

This component is capable of projecting the production of major commodities. The commodities can be grouped into two major sub-components - livestock and crops.

Livestock Commodities

a) Fed beef (steer and heifer slaughter)

b) Non-fed beef (cow slaughter)

c) Pork (barrow, gilt and sow slaughter)

d) Dairy (milk production - all grades)

e) Chicken (broiler and other chicken slaughter)

f) Eggs

g) Turkey

Crop Commodities

a) Feed grains (corn, barley, oats and sorghum)

b) Food grains (wheat)

c) Oilseeds (soybeans)

d) Cotton

2) Domestic Demand Component

This component consists of functions describing the various sources of domestic demand for the commodities listed in the domestic supply component. Demand for grain is generally broken into five sources, while demand for meat products is not subdivided. Grain demand sources include: 1) direct demand for human consumptions; 2) derived demand for use as livestock feeds by category of livestock; 3) public stock demands; 4) private stock demands; and 5) seed demand.

3) International Trade Component

This component's primary purpose is to interact with the domestic supply and demand component and project U.S. export of food grains, feedgrains and soybeans. In addition, estimates of imports for each of 19 regions for each of these categories are made where appropriate. Import projections for non-fed or low grade beef and feedgrains are also considered.

These three components are integrated to estimate prices, quantities produced, domestic consumption, exports, grain stocks and livestock breeding herd inventories for the appropriate commodity groupings listed. Projections are made on an annual basis. The supply model for each commodity is developed so that each can be used independently or integrated to create projections of all supply components. It is also possible to modify the model so that various components can be run independently, using assumption about the other components. Possible modifications of this type include 1) livestock supply and demand interaction only; 2) crop supply and demand interaction only; 3) domestic supply and demand interaction independent of trade linkages.

The Analytical Model Structure

The structure of the three components listed above and the structural linkage between the components can perhaps best be described by a presentation of the basic econometric functions of the model and by means of a graphic block diagram.

The abstract econometric structure of each commodity market is unique to the commodity. However, a general specification for a given commodity can be summarized as follows:

$$Q_D = f(P_{u.s.}, \overline{X}_1)$$

$$Q_x = f(P_{u.s.}, \overline{P}_c, \overline{X}_2, \overline{X}_3)$$

$$Q_s = F(P_{u.s.}, X_4)$$

$$Q_m = f(P_{u.s.}, \overline{X}_5, \overline{X}_6)$$

$$Q_s + Q_m = Q_D + X_x + I$$

where endogenous variables include

Q_D - Quantity demanded in the U.S.

Q_x - Quantity demanded for export

Q_s - Quantity supplied by U.S. producers

Q_m - Quantity imported by the U.S.

$P_{u.s}$ - U.S. price of the commodity

I - change in U.S. stocks (treated as a special case of demand)

and exogenous variable sets are

P_c - Price of the commodity in competing exporting nations.

X_1 - A set of factors that shift U.S. demand.

X_2 - A set of factors that shift competing exporter's supply.

X_3 - A set of factors that shift importer's demand.

X_4 - A set of factors that shift U.S. supply.

X_5 - A set of factors that shift U.S. import demand.

X_6 - A set of factors that shift the supply of imports available to the U.S.

The above supply and demand structure and associated identities allow solutions to be found for Q_D, Q_x, Q_s, Q_m, $P_{u.s.}$ and I (where I is treated as an additional source of demand and has a functional specification similar to Q_D) when the values of a set of exogenous variables and functional parameters are known.[1] Interaction between commodity models occurs when shifters in a given supply demand function for one commodity are endogenous variables in another supply and demand model, i.e., the quantity of feedgrain demanded for feeding livestock is affected by the price of soybean meal which is endogenously determined in the soybean supply and demand model.

Commodity interactions and linkages are of two general types, simultaneously and recursive. In general, simultaneous interactions occur between domestic demands for various grains and export demands for these grains. Recursive linkages exist between grain supply and demand, livestock supply and demand, and the feedgrain models and demand functions for livestock feed.

A second method of describing the analytical structure of the model is by use of a block diagram indicating major activities within blocks and linkages of stimuli and responses by connecting arrows.[2] The comb-like configurations pointing into various blocks indicate points of entry of exogenous factors. Described in this manner the model is envisaged to consist of three basic types of markets and the

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[1]Although all of the parameters of the functional relations contained in the model are linear and were estimated using regression analysis, the model diverges from a true econometric model in several cases. Strict adherence to econometric guidelines producing unbiased estimates were not always observed. The solution process for the model includes options to incorporate a number of non-linear constraints and adjustments.

[2]This diagram if developed in full detail and rigor would be an "exact block diagram" representing a mehtmatical model. This type diagram and its use was discussed in Chapter II in the Systems Methodology section.

supply and demand processes surrounding these markets. These markets include the livestock, feedgrain and food grain market (Figure 1). Cotton will be ignored for the moment since it appears similar in structure to the food grain market with the exception that there is no linkage existing between it and the livestock sector. Figure 1 attempts to illustrate four types of interactions simulated in the model including: 1) supply and demand interaction for each commodity category included in a given market; 2) the livestock - feed market interface in which livestock production activities give rise to feed demand; 3) the competitive process in which land and other resources are allocated to individual crop producing activities, and 4) the interface between U.S. domestic grain markets and international markets for grain.

The Feedgrain Market

The feed market is perhaps the most complex since it involves all of the four interfacing processes included in the model. Figure 2 presents a more detailed block diagram of the activities surrounding the feed market. The diagram indicates that domestic demand for feedgrains (corn, oats, barley and sorghum) and high protein feeds (soybeans) arises from four sources. There are seed demand, stock demand (public and private), livestock feeding demand and miscellaneous demand including use in the cereal food and brewing industry. The level of each of these demands, and therefore the sum of the demands is simultaneously determined along with the domestic market clearing price. This is illustrated by the two-way flow of causation between

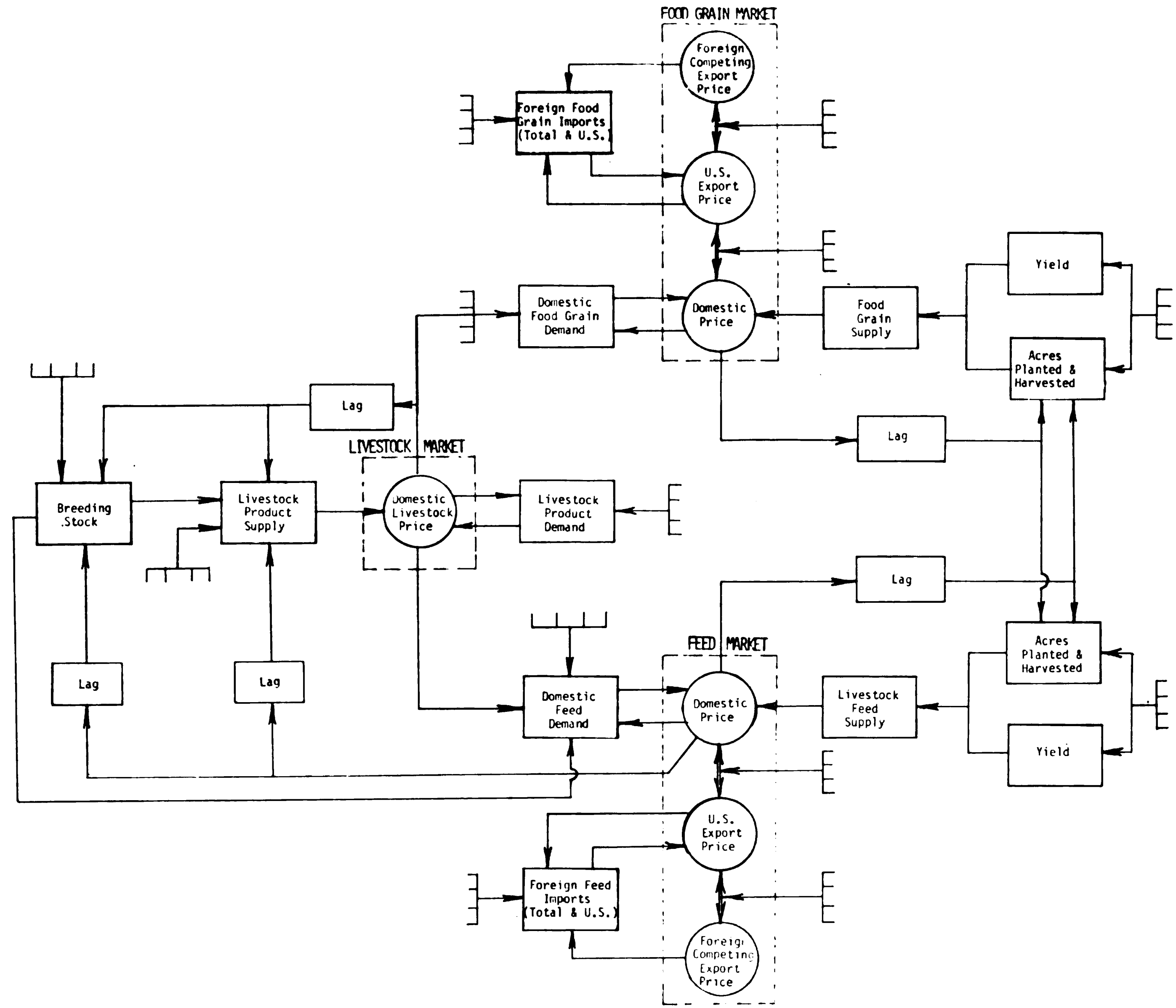

Figure III.1 Model subsector linkage structure

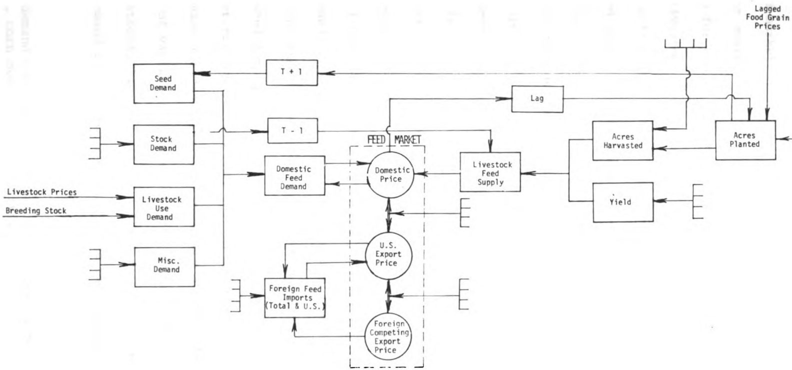

Figure III.2. Feedgrain and protein feed market linkage structure

the domestic feed demand block and the domestic price formation process in the feed market.

The major source of domestic demand for feedgrains and high protein feeds is for use in livestock feeding. A recursive linkage exists between livestock feed demand and livestock production and price formation activities. This linkage is established in the following manner. Feed demand is estimated for each category of livestock considered and then summed. This sum is linked with estimates of residual livestock feed demand to obtain a total livestock feed demand estimate. Specific livestock prices, production levels and breeding stock levels as well as competing feed prices enter into the feed demand function for a given livestock category. In turn the level of livestock production is affected by lagged feedgrain and high protein feed prices determined in the feed market, thus establishing a recursive link between the two markets.

Seed demand, stock demand and miscellaneous demand[1] are determined within the markets and have no direct intermarket linkages. However, since seed demand is a function of acres planted, it is affected by intercrop competition that determines acreages for each crop. Stock demand and miscellaneous demand are affected by own prices and sets of variables exogenous to the entire model including, in the case of stocks, lagged stock levels and government policies. Miscellaneous demand is affected by U.S. income and population growth.

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[1]Miscellaneous demand consists of demand for feedgrains to produce breakfast foods, corn meal, grits and distilled spirits.

Supply of various feed grains (corn, oats, barley and sorghum) and high protein feeds (soybeans) is largely determined by the competitive land and resource allocation process in the crop subsector and the carry-over stock level. Acreage planted to a given crop is a function of government policies in effect for the crop and other crops closely competing for land, and by the preceding year's own price and prices of other closely competing crops.

Given the acres planted, acres harvested are determined through weather proxies and trends in technology affecting acreage abandonment rates. In the case of corn and sorghum where part of the acres planted are diverted to silage production, special consideration is given to factors creating demand for silage. For corn and sorghum acreas planted are thus divided into grain, silage acres and unharvested acres.

Yield is estimated as a function of policy factors, fertilizer price, weather, and in some cases, acres planted. Given estimates of yield and acres harvested, production can be determined and added to carry-over stocks to determine the supply of a given feed. This supply estimate becomes a factor in determining the market clearing price. The flow of causation is one-way between the livestock feed supply block and the domestic feed grain price formation process. This is the case because of the recursive loop carrying lagged prices back into the acreage functions (and in some cases to the yield functions).

Domestic and international grain market linkage is established through a set of prices depicted by the double headed arrows within

the dotted lines bounds of the feed market. The prices which a given country reacts to in determining its total volume of import purchases and in determining from whom it will purchase are the "delivered" or port of entry prices of the commodity. These "delivered" prices can be linked to a given exporting nation's domestic price. However, a number of factors cause the spread between domestic and delivered export price to vary from year to year and from country to country. Variation between the U.S. price and delivered price to foreign countries is estimated by considering export policies, exchange rates, transportation cost, general inflation rates and the distance to each country. Through an estimated function that takes into account each of these factors the U.S. price for grains is established in the world market and linked to the U.S. domestic price. Once these linkages are established the U.S. domestic price and the set of U.S. delivered prices for individual regions rise and fall proportionately in the model's solution process.

Delivered prices of competing exporters to a given region also affect the region's total imports and the share of this total purchased from the U.S. This modeling effort has not attempted to determine foreign competing exporters' domestic commodity prices, and in turn, link them to their world export prices. Instead, a price spread has been established between the U.S. delivered export price and the weighted average level of competing exporters' prices to a given importing country or region. This price spread is estimated as a function of the location of the importing country in question, historical trends in the competitive price relations and conditions in the competing export nations.

Given the establishment of these two measures or concepts of world grain market prices an estimate of the demand for U.S. grain exports was modeled in a two-step process. First, total demand for a given commodity (feedgrains or wheat) in a given region was estimated as a function of the weighted average implicit import price of imports from all sources, production of the commodity in the region during the current and preceding year and gross domestic product of the region. Second, estimates of total imports from the U.S. are made by considering the U.S. delivered export price, competing export nations' delivered price and the quantity of total imports. Estimates of U.S. exports to 19 regions are summed and added to an estimate of residual U.S. exports to obtain an estimate of total U.S. exports. Residual U.S. exports consist primarily of exports to Communist block nations. Exports to Communist nations are determined exogenously.

In the case of soybeans, the domestic-international market linkage is less sophisticated. Because U.S. soybean exports have been affected little by U.S. export policy and little competition historically has existed in the world market for soybeans, no price link is made between U.S. domestic price and U.S. delivered export price. Also no competing export price is considered, hence soybean imports in a given region are directly related to U.S. domestic soybean prices. Production of soybeans in importing countries was also found to be inconsequential with respect to soybean import levels; hence only demand factors in the importing country and the U.S. price of soybeans are included in the soybean import functions.

The Food Grain Market

The structure of the food grain market is very similar to that of the feed market and will not be reviewed in detail here. The major difference lies in the relative importance of each source of demand. The major source of demand domestically in the food grain market is for human consumption as opposed to livestock consumption in the feed market. An estimate of wheat consumption by livestock is made but it is not broken down by category. Also, historically government stock demand and export demand have been relatively more important in the food grain market than in the feedgrain market.

The Livestock Market

The structure assumed for the purpose of modeling the livestock market is quite different than those assumed for the grain markets. This can be attributed to three fundamental differences assumed to exist between grain and livestock market conditions: 1) International markets for livestock products, with the exception of low grade beef imports, are assumed to be of such small consequence that they are not modeled. 2) Carry-over stocks of livestock products are assumed to be inconsequential. Carry-over effects are modeled through breeding stock levels. 3) Multiple enterprise or resource allocation competition is assumed not to exist in livestock production with the possible exception of pork and fed beef. Unlike land, machinery and other relatively fixed assets used in crop production, the assets used to produce a given livestock product are relatively fixed to a specific livestock enterprise and cannot be shifted readily from one to another.

These assumptions lead to specification of a recursive price determination process in the livestock market. That is, supply of all livestock products is first estimated using no current period endogenous variables. These supply estimates are then coupled with exogenous demand factors (specifically deflated per capita income) to estimate domestic market prices for livestock products. Cross flexibilities are estimated between competing meat products. Non-meat food items are assumed to have no competitive impact upon meat demand.

Livestock supply estimates are based on lagged product prices, grain prices, and, in some cases, on lagged interest rates (a proxy for capital costs) and wage rates (a proxy for labor costs). In the case of beef, dairy and pork, breeding herd levels at the beginning of the year are also considered as a factor affecting supply. Estimates of breeding herd levels are made elsewhere in the livestock sector of the model. Distributed lags of input and output prices are also used to estimate breeding herd levels. The beef, pork and dairy breeding herd and product supply estimates are based on polynomial distributed lag models. In the case of chicken meat, eggs and turkey meat, geometric lag models were used.

Model Identification

In specifying or "identifying" the model, decisions had to be made defining which variables represent inputs (exogenous) and outputs (endogenous) of the model, and in turn, what parameters are needed to define the structure relating these inputs and outputs.

Specification of variables as exogenous or endogenous is a key decision in the modeling effort. In making this decision the scope of the model and its analytical capabilities are essentially set. A specification which is too broad can lead to a system too complex to manage and/or too detailed; thus obscuring basic issues to be addressed. A specification which is too narrow will force one to omit important factors and interactions essential to determining realistic system behavior. The exogenous variables essentially "drive" the model and determine any major change which will occur in the "simulation"[1] output of the model. In addition, the exogenous variables provide the link between the system being modeled and the environment within which it performs.

Exogenous variables can be classified in two chronological categories: 1) starting or initial state values and 2) time related or dated exogenous variables which may fluctuate in value as the model simulates through time. If the time related exogenous values are held constant (referred to as steady state condition) the endogenous portion of the model (if the model is dynamic)[2] will proceed to interact and

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[1]Simulation is a widely used term but is used here to refer to the process of generating a time path of model variables created when a specific set of systems inputs and model parameters are used interactively in solving a model.

[2]A dynamic model is loosely defined as a system having variables that change through time as a result of changes in inputs and the interactions among system elements. More precisely, these are systems with time delays or memories so that outputs depend upon previous values of input variables (Manetsch and Park, Systems Analysis and Simulation with Applications to Economic and Social Systems, Part 1, p. 10). If "feedback loops" exist then the delayed input variables may be previous output values.

generate a time path of solutions which is either "explosive," "stabilizing," or continuously "cyclical." An economic model would be expected to exhibit "dampening cycles" which would eventually cycle to an equilibrium value if all exogenous variables were held constant. This follows from the assumption that the economy is a stable system, but at any point in time is generally not in equilibrium because of various external shocks which have occurred. The system, however, should be moving toward equilibrium at all times. The speed with which it reaches equilibrium depends on the rate of adjustment of each activity as well as the interrelation between activities.

Several criteria exist for selecting or distinguishing between endogenous and exogenous variables. A statistical model requires certain relations to exist between the exogenous and endogenous variables and their placement in the system for the system to be "identified" in an econometric sense. Proper identification in the econometric sense is required in estimating and solving sets of simultaneous equations.

A pragmatic criteria for selecting exogenous variables for use in forecasting models is that they must be more readily forecast outside the model than the endogenous variables. Otherwise it is fruitless to use them to estimate the endogenous variables. Such estimation would better be approached directly.

System's methodology provides a number of "structurally" related guidelines to "identification" of a system. Inputs or exogenous factors are divided into two types, "environmental" and "overt" inputs. Environmental inputs are "variables which affect the system but are not significantly influenced by the system."[1] Overt inputs are defined as those "necessary for the system to carry out its intended functions. These are provided for by the designers or managers of the system."[2] Overt inputs can further be divided into "controllable" and "uncontrollable." It should be noted that the defining of overt inputs and the distinction of controllable or noncontrollable necessarily involves determining the "designers or managers" of the system.

The following diagram, which is a modification of a similar diagram presented by Manetsch and Park, summarizes the factors involved in "system identification."

A hypothetical example similar in nature to one of the subsystems in the NASS model may help illustrate the content of the diagram. Assume the system to be modeled is corn production and marketing and the management of these physical and institutional activities. The managers in this case are the corn producers. Inputs into the system might include land, labor, machinery, seed, water (rainfall and irrigation), policy factors and various industrially produced inputs such as fertilizer, fuel, etc. Other inputs affecting the marketing of corn include demand factors such as livestock populations, foreign demand, etc. Outputs of the system might include corn production, corn price, input use levels, exports, stocks etc.

The manager of the system analyzes the output generated by given inputs and his perception of the environment, and acts in turn

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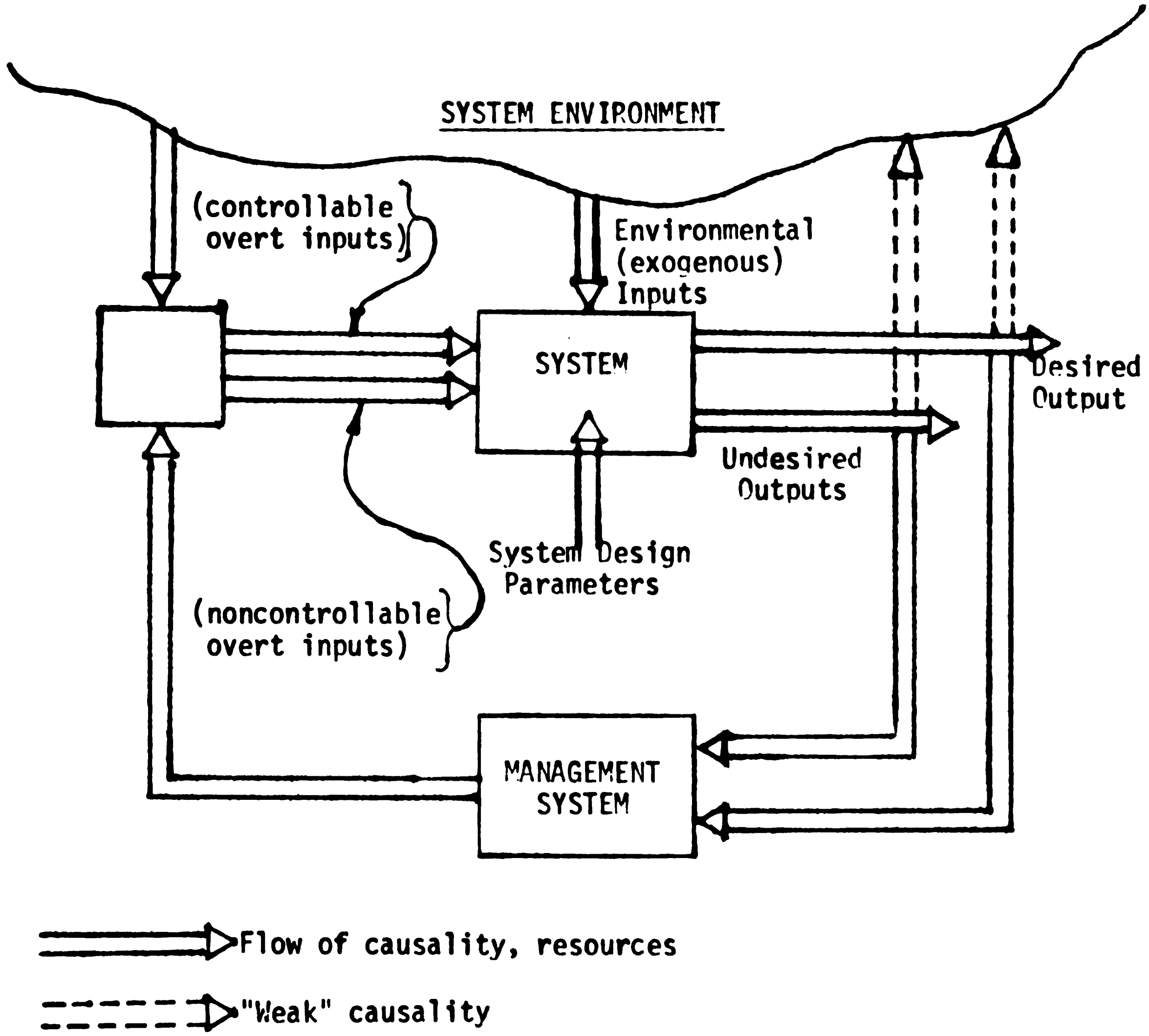
[1] Manetsch and Park, Systems Analysis and Simulation with Applications to Economic and Social Science Systems, p. 9.

[2] Ibid.



Source: Manetsch and Park, System Analysis and Simulation With Applications to Economic and Social Systems, p. 10.

Figure III.3. System identification as part of the systems approach (feasibility evaluation phase)

to alter the nature of controlled overt inputs to fulfill his objectives in terms of obtaining more desired outputs and less undesirable outputs. (Note that the system does not contain an objective function or optimization procedure but does contain response parameters which describe the alteration in overt inputs generated by various output combinations and environmental states.) Examples of controlled overt inputs in this system may include land, labor, machinery, seed, irrigation water and industrial inputs used. An example of an uncontrolled overt input is compliance with policy regulations. (Policy makers are assumed here to be a body of managers separate from the corn producers and not readily controlled by them.) Environmental factors (exogenous factors not overtly provided by the manager but affecting the system behavior) include rainfall, various demand factors, industrial input prices etc.

There are several general principles or guidelines prescribed by system's methodology for identifying systems and classifying the nature of and type of variables to be contained in the system. The first basic principle deals in distinguishing between "environment" and "system." System and environment should be defined so that no strong causal loops exist from the system to the environment. Stated otherwise, no strong feedback loop should exist outside of the system; rather all strong direct and indirect feedback loops should be included in the system. The model should include environmental factors which have a strong impact on the system, but the determination of these factors should be exogenous to the model or system.

A second basic principle is that all factors which can potentially be used by decision makers of the system to alter system performance should, at least initially, be "in the system." Stated otherwise, all overtly controlled factors should be endogenous to the model while overtly-noncontrolled factors should be and are by definition exogenous to the system.

In the NASS model a conflict arises between the first and second principle stated here. Policy variables are essentially assumed to be beyond the control of the manager (producer) but are also in fact strongly linked to system output levels. Hence, via the second principle policy factors are exogenous variables, but via the first principle they should be endogenous since strong feedback loops or causation linkages exist between such outputs as stocks, farm income, etc. and agricultural policies. The resolution of this conflict is embodied in the third guideline or principle.

The third principle deals with defining the proper breadth of the system and with its effects upon the accuracy of the system. At some point one must restrict the scope of his system to make its implementation manageable. To do so, of course, limits ability to consider all factors important to system behavior. One must consider where additional effort will result in significantly better estimates. Likewise, when dealing with uncontrollable environmental variables (uncontrolled by the system management) the decision has to be made as to whether further study of the causes of these factors, i.e., rainfall patterns, income and population growth, etc. will improve estimates enough to be worth inclusion into the system.

A point in question in the NASS model in regard to the third principle is to what extent does one include in the system factors creating export demand. Export demand is beyond the control of participants in the domestic agricultural sector; yet it is an important factor in making estimates of the domestic agricultural system's behavior. The NASS modeling effort has assumed that greater understanding and modeling of the nature of export demand would greatly enhance domestic agricultural system estimates and has therefore conducted considerable modeling effort with respect to this question.

Another point in question with respect to the third principle is that of the treatment of policy factors. As alluded to previously, policy determination is strongly linked to system output variables but is beyond the immediate control of "system managers" where these managers are viewed as agricultural producers. If we broaden the scope of the model to include policy makers as system managers, we then make policy factors controllable overt inputs. But in broadening the model to do this, we increase its complexity and are faced with the question of the added estimating ability this gives the model versus its added effort. In addition, the question arises as to whether an empirical model is the best technique with which to model the policy feedback loop. The question of model purpose arises; does one want to model and predict policy per se or does he wish to model and predict reaction to policy.

A general overview of the boundaries set, using the guidelines previously discussed to distinguish which activities and factors are endogenous to the sector to be modeled, and which activities and factors are exogenous to the model is given in Figure III.4. The figure also relates the general "physical" structure of the system. The portion of the figure between the wavy lines is denoted as the "Ag Sector" and outlines the essential physical structural relationships of the model and variables to be considered as endogenous. Factors listed outside of the wavy lines are exogenous or input variables to the model.

A verbal description of Figure III.4, beginning from the left portion of the diagram is as follows. The numerous factors considered to be exogenous to the model but affecting the demand for product categories included in the model are listed by general type. They are split into those affecting domestic and foreign demand. They include population, income, policies of various types including trade regulations, stock related policies and income redistribution programs, foreign agricultural production and the domestic inflation rate or the general price level.

Within the "Ag Sector" or endogenous portion of the model the physical structural linkage flowing from left to right on the diagram indicates that domestic demand for direct human consumption is of two types, livestock and foodgrain demand. Foreign demand is specified as being for grains (foodgrains and feedgrains) and high protein feeds. The summation of these demands gives rise to livestock and crop production activities. These production activities in turn give rise to derived demands for inputs. A major input demand of the livestock production activity is for grain and protein feeds produced by the crop production activities. Other derived demands of the

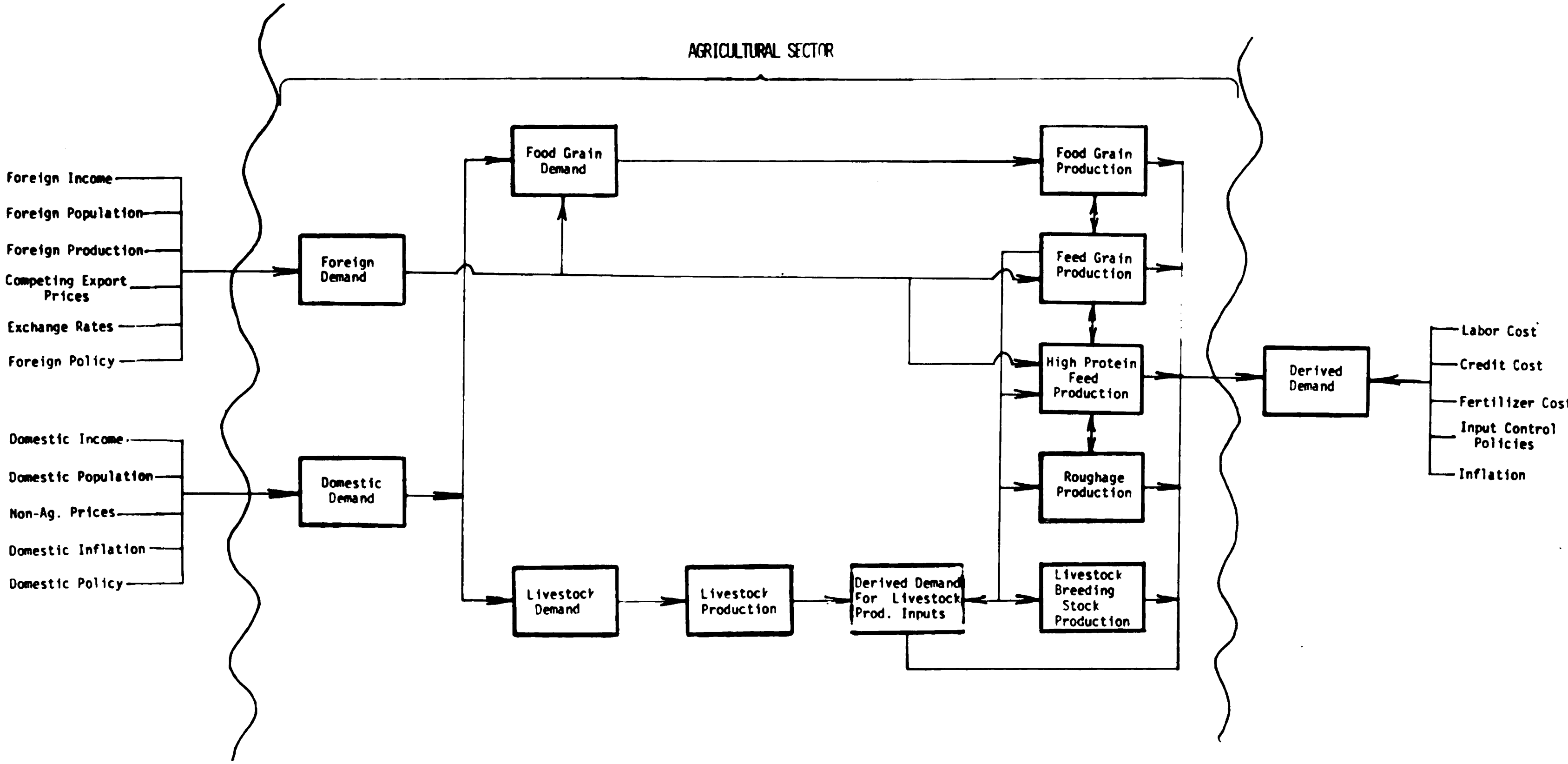


Figure III.4. Identification of the agricultural sector livestock production activity are for roughages and breeding animals.

The crop and livestock production activities give rise to derived demands which reach "outside" of the Ag Sector or endogenous portion of the model as defined by this project. These demands include the demand for labor, financial credit and industrially produced inputs such as fertilizer, machinery etc. The conditions existing in the markets for these inputs affect the production activities giving rise to these demands; hence a number of factors reflecting input market conditions appear as exogenous variables to the model including labor costs (wage rates), credit cost (interest rates), fertilizer cost, fuel cost, input control policies (including acreage restrictions and crop subsidies), general price levels etc.

Econometric System Identification and Estimation

The proceding discussion has dealt with system identification in a general and structural sense. Identification guidelines outlined in the systems orientation are more general than "econometric systems identification" requirement. However, systems identification procedures can be completely compatible to econometric identification requirements. Econometric identification requirements tend to focus upon the mechanical requirements and properties for estimating parameters while systems guidelines focus upon structural factors. The following comments will focus upon the identification status and estimation procedures used in the NASS model in respect to their relation and divergence from the "econometric" methodology.

The model with respect to estimation procedures is basically an econometric model. It consists of a set of integrated econometrically estimated linear functions. The theory and assumption made about the abstract structure to be modeled called for both "recursive" and "simultaneous" relations to be specified and estimated. A recursive relation is defined as a structural function containing at least one lagged endogenous variable (hence exogenous to the period in question) as an independent variable but with no current period endogenous variables included as independent variables. A simultaneous relation is defined as a function containing at least one current period endogenous variable as an independent variable.

The model in its final form diverts from a truly econometric model in several ways. First, strict adherence to econometric theory has not been followed in all cases; hence all parameter estimates are not "best linear unbiased estimates". The main divergence from econometric theory in estimating parameters was the failure to use simultaneous techniques such as two-stage least squares in many of the cases where simultaneous relations were specified. This results in biased parameter estimates to the extent that the endogenous independent variable is correlated to the residual or error of the estimated relations. Although two-stage least squares was not used, the model is properly "identified" in an econometric sense so that such a technique could be used.

Two stage least squares or other simultaneous estimating techniques derive an instrumental variable for independent endogenous variables in the function. Ideally an instrumental variable is nearly independent of the function's error term but highly correlated with the independent variable for which it is an instrument. To the extent that the instrumental variable achieves its desired properties the bias of the estimate of the parameter for the endogenous independent variable is reduced. However, the bias is reduced or eliminated at the cost of some efficiency. The instrumental variable never perfectly matches the variation of the endogenous independent variable it represents; hence some information is lost. The decision, in a practical sense, whether to use a simultaneous estimator such as two stage least squares is one of whether the elimination of bias achieved is worth the efficiency lost. The mere theoretical specification of a simultaneous relation does not, in all cases call for -- in a practical sense -- the use of a simultaneous estimator, if one is willing to accept the bias created by the use of an ordinary least squares estimator.

Another divergence in estimating technique from rigorous econometric theory was the failure to correct for the existence of serial correlation where it was indicated to exist according to the Durbin-Watson test. Attempts were made to avoid serial correlation in all regressions models estimated. Models with low serial correlation _ceteris paribus_ were favored. However, in some cases models with serial correlation could not be avoided and this problem was not corrected by an auto-correlation adjustment technique.

Similar statments may be made for the existence of multicollinearity. In many cases, ratios or the elimination of variables were used to reduce strong multicollinearity, but some cases did remain with no special estimation technique being invoked to attempt to reduce the problem.

A second major way the model diverges from a true linear econometric model is in the solution and model management routine developed for the system. The solution algorithm for the model essentially uses linear matrix algebra to solve the simultaneously specified functions in the model. However, a number of relations that were estimated by linear techniques are distinctly non-linear in nature over certain ranges of the dependent variables. One such case is that of stock demand by the government. This leads to the desire to use iterative adjustment procedures to make these few most serious cases of non-linearity into non-linear relations. A procedure making such adjustments has been developed in the solution routine for all stock models. In addition, a number of non-linear cross consistency checks proved useful and in some cases specific non-linear adjustments to the model solution are iteratively imposed to remove inconsistencies found. Any of these iterative adjustment procedures cause the model to deviate from the nature of a rigorous econometric model and hence reduce the validity standard econometric tests and procedures.

Linking the Abstract Structure to the Empirical Structure

The preceding discussion has outlined the procedure for "identification" of the "abstract" system to be modeled and provided an overview of the abstract structural relations (summarized in Figure III.1) to be included in the model. The next step of the modeling process consists of developing a more detailed specification of the structure and proceeding to transform the abstract structure into empirical relations for which parameters can be obtained.

Economic theory enters at this point in model development as an important tool in providing a consistent basis for identifying specific empirical relations to represent the abstract structure and in providing hypothesis about the parameters contained in the empirical relations. The meshing of statistical inference testing and economic theory provides the primary method used to obtain parameters for empirical relations in this model. This is especially the case where these relationships represent managerial processes in which the quantity of overt-controllable inputs are determined. Such relations are often referred to as "behavioral" relations and attempt to predict the actions or behavior of a set of producers given a set of conditions. Economic theory is quite helpful in defining the factors that influence such economic behavior in a "static" sense. Theories regarding dynamic behavior, risk, uncertainty and stock holdings are less developed and hence less helpful.

The ability to relate empirical relations and the variables contained within them to general economic theories assist in making consistent specification of empirical functions and make clear the assumptions involved in the empirical specifications. The following discussion attempts to outline the supportive theory and the assumption made in specification of empirical relations describing: 1) livestock supply response; 2) grain supply response; 3) export demand; 4) stock demand; 5) direct domestic demand, and 6) derived domestic demand. Description of the specification of these relations will be done in the context of the three markets outlined in Figure III.1 and the earlier discussion of this figure.

Livestock Supply and Derived Input Demand

Specification of livestock supply response functions and the derived demand relations generated by livestock production activities is based on micro level assumptions concerning the technical nature of livestock production activities and producer's objective functions. Relations (1) and (2) are the general production function and objective function assumed for livestock activities.

(1) $Q_{LIV} = f(Q_{F.G.}, Q_{H.P.}, Q_R, Q_L, Q_K/Q_{B.S.})$

(2) $\Pi = P_{LIV}\, Q_{LIV} - P_{F.G.}\, Q_{F.G.} - P_{H.P.}\, Q_{H.P.} - P_R\, Q_R - P_L\, Q_L -$

$P_K\, Q_K - FC + \lambda\, (Q_{LIV} - f(Q_{F.G.}, Q_{H.P.}, Q_R, Q_L, Q_K/Q_{B.S.})$

where

Q - Quantity

P - Price

FC - Fixed Cost

λ - Lagrangian Operator

and the subscripts are defined as follows

LIV - Livestock

F.G. - Grain fed to the livestock category

H.P. - High protein feed fed to thelivestock category

R - Roughage fed to the livestock category

L - Labor used in producing the livestock

K - General capital used in producing the livestock

B.S. - Fixed assets present in the livestock category as proxied by the breeding herd level for each category.

Livestock production is assumed to be a function of the quantity of feedgrain, high protein feeds, roughage and the quantity of labor and general variable capital inputs used. In addition, livestock production is a function of the fixed assets existing in the specific livestock category. Fixed assets in the annual time frame of the model are defined to include feeder animals, feeding facilities, and other specialized capital and/or machinery used to produce the livestock product being considered. The magnitude of this set of fixed assets is assumed to be proxied by the quantity of breeding stock in existence at any given time. (Because of the aggregation of inputs and proxy variables used in relation (1) it cannot be defined as a production function but more correctly as an aggregate input-output relation.)

The objective function assumed for livestock producers is represented by relation (2). A single enterprise objective function is assumed based upon the argument that livestock production activities in general require specialized assets not readily adaptable to other production activities. Therefore, the livestock producer views his revenue as being from a single source and does not consider other enterprises.

The existence of specialized fixed assets for the enterprise constrains the producer from maximizing revenue by its effect on the marginal productivity of variable inputs and by the creation of fixed costs specific to the enterprise. In addition, the objective function is constrained by the physical limitations of the input-output relation.

Several exceptions or modifications to the above general micro level assumptions are made in livestock supply estimates in the NASS model. In the case of pork, the existence of a second enterprise alternative or multiple enterprise objective function is allowed. The alternative enterprise is fed beef production. Also in the case of poultry, asset fixity, within a year's time span, is not assumed to be as severe a constraint as is the case of beef, pork and dairy. Hence, the proxy for asset fixity is dropped from the input-output relations for poultry product categories.

The specific assumptions made for the micro level input-output relations and objective functions can be transformed to macro supply response functions and derived demand functions. The micro level assumptions can then also be reinterpreted and analyzed in a macro context.

In a mathemtical or econometric sense, this transformation is accomplished by assuming the producer is attempting to maximize his objective function, subject to the constraints imposed. The mathematical conditions for optimizing such an objective function require that the partial derivatives of the objective function to equal zero. The marginal value product of each input must equal its price for the constraints to be satisfied. This system of equations is derived as illustrated below.

$$\frac{\partial \Pi}{\partial Q_{F.G.}} = P_{LIV} \frac{\partial Q_{LIV}}{\partial Q_{F.G.}} - P_{F.G.} = 0$$

$$\frac{\partial \Pi}{\partial Q_{H.P.}} = P_{LIV} \frac{\partial Q_{LIV}}{\partial Q_{H.P.}} - P_{H.P.} = 0$$

(3)
$$\frac{\partial \Pi}{\partial Q_{R}} = P_{LIV} \frac{\partial Q_{LIV}}{\partial Q_{R}} - P_{R} = 0$$

$$\frac{\partial \Pi}{\partial Q_{L}} = P_{LIV} \frac{\partial Q_{LIV}}{\partial Q_{L}} - P_{L} = 0$$

$$\frac{\partial \Pi}{\partial \lambda_1} = Q_{LIV} - f(Q_{F.G.}, Q_{H.P.}, Q_R, Q_L, Q_K/Q_{B.S.}) = 0$$

The system contains six functions and six unknown quantities. (Prices are assumed to be exogenous and known at the micro level.) This system of equations can be rewritten in reduced form making all endogenous quantities a function of exogenous prices or exogenously determined fixed asset levels. If this is done the general form of the functions will appear as follows:

(4)
$$\begin{aligned}
Q_{LIV} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.}) \\
Q_{F.G.} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S}) \\
Q_{H.P.} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.}) \\
Q_{R} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.}) \\
Q_{L} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.}) \\
Q_{K} &= f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.})
\end{aligned}$$

These are the supply response and derived demand functions theoretically implied by the micro level conditions specified. Note that the assumptions concerning the existence of fixed assets specialized to the enterprise leads to the appearance of the quantity term selected to proxy the fixed asset level in the macro supply and derived demand functions.

If fixed assets are viewed as an input into the livestock producing activity which becomes variable in nature over a longer time span the same factors are theoretically assumed to create the demand for this input. Assuming the input to be fixed for a one-year time span, changes only the "dynamics" of the economic theory involved in specifying the derived demand relation for the input. Over a longer time span, what is classified as a fixed asset and constraint to profit maximization becomes variable and is not a constraint to profit maximization. Hence, the quantity of breeding stock demanded in a static sense can be specified as follows:

$$(5) \qquad Q_{B.S.} = f(P_{LIV}, P_{F.G.}, P_{H.P.}, P_R, P_L, P_K, Q_{B.S.(t-1)})$$

The above relationship cannot be properly specified without considering the dynamics of the demand for capital assets. A discussion of dynamic economic adjustment theory and the associated body of econometric techniques presently developed to deal with such theory will be deferred at the present.

The livestock sector of the NASS model interfaces directly with the feed sector of the model. The derived demand for feedgrains, roughage and high protein feeds generated in the livestock sector are a major source of demand for these grains. (Other sources of demand included export demand, stock demand, direct human consumption demand

primarily for brewing purposes, cereals, the oil by-products and seed demand.) The interaction of the livestock sector's derived demand for feeds (coupled with other demands) and the supply of feeds form the market or price generating process for feeds.

Feed Grain Supply and Derived Input Demand

The theoretical guides used in specifying the feed supply response functions, or for that matter, crop supply response functions in general, are the same as those used in specifying livestock supply response functions. However, the assumptions made are quite different and therefore, different empirical specifications are derived.

Specifically the typical crop producer is assumed to view his objective function as a multiple enterprise objective function. His assets are generally not so specialized as to prevent them from being shifted from one enterprise to another. Another condition in the crop supply sector that must be dealt with is the existence of direct government control of crop production activities. With these factors in mind, the following production relations and associated objective function are specified for the general micro crop enterprise system.

$$(6) \qquad Q_{\#1} = f(Q_{LD}^{\#1}, Q_{LB}^{\#1}, Q_{K}^{\#1})$$

$$(7) \qquad Q_{\#2} = f(Q_{LD}^{\#2}, Q_{LB}^{\#2}, Q_{K}^{\#2})$$

$$(8) \qquad \Pi = (P_{\#1} + SP_{\#1})\, Q_{\#1} + (P_{\#2} + SP_{\#2})\, Q_{\#2} - P_{LD}\, Q_{LD} - P_{LB}\, Q_{LB} - P_K\, Q_K + \lambda_1(Q_{LD}^{\#1} + Q_{LD}^{\#2} - R) + \lambda_2(Q_{\#1} - f(Q_{LD}^{\#1}, Q_{LB}^{\#2}, Q_{K}^{\#2}) + \lambda_3(Q_{\#2} - f(Q_{LD}^{\#2}, Q_{LB}^{\#2}, Q_{K}^{\#2})$$

where

Q - Quantity

P - Price

SP - Support Price

R - A phsyical or political restriction on acreage

λ - Lagrangian operator

Π - Objective value

WC - Weather Conditions

and the subscripts are as follows:

LD - Land

LB - Labor

K - Capital

#1 - Crop enterprise number one

#2 - Crop enterprise number two

Production is assumed (given weather conditions) to be a function of the land, labor and capital used in each crop enterprise. (Specific proxies and aggregations will not be related here.) All inputs will be assumed to be variable to the enterprise, but not necessarily to the firm.

The objective function indicates that revenue can be obtained from two enterprises and that the revenue may be generated either through open market transaction or government support of various types. The objective function is constrained by the overall constraint to the firm of land available (land inputs are assumed fixed to the firm) or policy constraints to the firm on land planted. (It is assumed here that the policy restriction is not crop specific.) The objective function is also subject to the input-output relations existing for each enterprise.

One can again proceed to determine the conditions necessary to maximize the constrained objective function and rewrite this set of functions in the form of supply response and derived demand functions. The result of these mathematical operations is as follows:

$$
\begin{aligned}
(9)\quad & Q_{\#1} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{\#2} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{LD}^{\#1} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{LD}^{\#2} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{LB}^{\#1} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{LB}^{\#2} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{K}^{\#1} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R) \\
& Q_{K}^{\#2} = f(P_{\#1}, SP_{\#1}, P_{\#2}, SP_{\#2}, P_{LD}, P_{LB}, P_K, R)
\end{aligned}
$$

A pragmatic question arises at this point which appears to be weakly dealt with by theory. Supply of crops (or meat, for that matter) is generally thought of as consisting of units (acres, head, etc.) times yield (bushels, pounds etc.). The theoretical derivation presented here includes no such distinction.

The question is basically one of the resource combination used; how much land in this case versus how much yield generating inputs are used to arrive at a total Q. Theoretically, there appears to be no reason to believe that the factors generating the use of inputs to increase the number of units in production versus the yield of each unit differ. However, the response of producers to various factors may be different in terms of choosing how to produce or whether to use resources devoted to increasing acreage versus increasing yields. For example, an increase in fertilizer price should theoretically be reacted to by reducing fertilizer inputs and other complimentary inputs, and perhaps increasing substitute inputs including land. Theoretically, yield should decline in reaction to fertilizer price more than enough to offset the acreage increases, therefore creating a decline in total output. The dynamic response pattern, however, may differ for yield and acres because resources associated with altering yield are more variable in nature than those associated with land use. Also policy constraints may be acreage or yield specific in regard to the type of inputs or activities constrained.

If any of the suggested reasons or other reasons for differing response parameters for unit versus yield response exist, and these differences are essential to the structure of the model, or if consideration of the differences is felt to give better estimates, then on pragmatic grounds such a distinction should be made (Gemmill[1] discusses in Appendix A of his dissertation the theory and arguments for estimating both yield and unit functions, versus estimating a single supply response function). In this modeling effort, yield and acres harvested (derived from acres planted) are estimated separately. The primary reasons for doing this are the differences in dynamics of the

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[1]Gordon Gemmill, <u>The World Sugar Economy: An Econometric Analysis of Production and Policies</u>, Unpublished Ph.D. dissertation, Michigan State University, 1972.

two relations (the dynamics theory and assumptions for these two relations will be discussed later) and the different weather proxies relevant for each type of function.

As alluded to, the determination of acres harvested in this model is a two-step process, with the first step being to estimate an acres-planted function. This function is theoretically a derived demand function for land input. Acres harvested then becomes a function of acres planted and short-run factors affecting the objective function and production relation such as weather and new expectations about output prices.

The yield function specified in the model is theoretically the same as the acreage planted function. Multiplication of yields and acres harvested generates production estimates.

Estimating Distributed Lag Functions

Previous theoretical derivations in this chapter have shown that the static aggregate supply functions can be specified from the firm's production function and objective function specification. If one were to assume perfect competition, profit maximization, perfect knowledge and no fixed factors of production, in short, all of the assumption of static economics and perfect competition, the supply curve and marginal cost curve of the firm would be the same, and one could be content with the static aggregate supply function previously specified.

Relaxation of the static assumptions brings us to a consideration of dynamic supply analysis. Supply adjustment through time and the factors affecting both the speed and magnitude of the adjustment process are considered in a dynamic analysis. In many economic relations, particularly agricultural supply response, it has been noted that the reaction to a change in a causal factor is spread over a number of time periods. This lapse of time between cause and effect is referred to as a lag and may be of fixed duration or "distributed" over time.

Many theories and rationale have been suggested to explain the reason for "distributed lags." Kyoch[1] and Nerlove[2] have suggested three general reasons for the existence of distributed lags - technological reasons, institutional reasons and subjective or psychological reasons. The technical reasons relate to the face that production of physical goods requires time. For example, in producing livestock, gestation, feeding, slaughter and processing delays exist from the time the decision is made to produce more output until the product is finally produced. Institutional reasons for distributed responses include such factors as customs, established contracts, etc. which serve as blocks to immediate reaction to a stimulus for change. Producers are unable to immediately alter their production rates when price trends change. Hence, the supply response function is irreversible.

Glenn Johnson's concepts as presented in the "Over-Production Trap"[3] illuminate several key institutional characteristics of farm

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[1] L.M. Kyoch, Distributed Lags and Investment Analysis, (Amsterdam: North Holland Publishing Company, 1954).

[2] M. Nerlove, The Dynamics of Supply: Estimation of Farmer's Response to Price, (Baltimore: Johns Hopkins Press, 1958).

[3] Glenn L. Johnson and Leroy C. Quance, (ed.), The Overproduction Trap in U.S. Agriculture, (Baltimore: The John Hopkins University Press, 1972).

production which assist in explaining the dynamic behavior of agricultural producers. Johnson argues that the existence of fixed assets and uncertainty lead to a tendency of farmers to over-produce.

The third reason for the existence of distributed lags is subjective or psychological. This category includes the existence of uncertainty and the nature of the formulation of expectations by managers. Price changes or other changes in stimuli to produce may be perceived as being temporary or permanent in nature and of various magnitudes. The perception of the degree of permanency and magnitude is assumed to affect the nature of the decisions made in adjusting production.

Each of the three preceding reasons for lagged response suggested by Kyoch and Nerlove creates distinct forces which lead to a particular distributed lag. The econometric techniques developed to estimate lagged output response over time do not distinguish between these three forces. The distributed lag structure estimated is an aggregate measure incapable of determining the precise causes of the lagged response.

Econometric lag estimating techniques and rationale for them have generally been developed through arguments dealing with institutional and psychological reasons for lags. System science lag techniques or "delay procedures" have generally been developed through arguments dealing with technical reasons for lags. A proper meshing of the two lines of arguments would appear to allow specific consideration of technological factors on the one hand and insitutional and subjective factors on the other. Current econometric and system's techniques do not appear to allow for effectively distinguishing the institutional and psychological forces creating the lags.

The approach taken in this modeling effort does not attempt to distinguish between any of these three general reasons for the existence of "distributed lags." However, all three reasons are recognized in interpreting and selecting the econometric lag models used.

Distributed Lag Models

The general form of an econometric distributed lag model is specified as follows where output Q responds to a single price.

(10) $$Q_t = \alpha + B_1P_t + B_2P_{t-1} + B_3P_{t-2} + \ldots B_NP_t + e_t$$

or

$$Q_t = \alpha + \sum_{i=0} B_iP_{t-i} + e_t$$

The B_i's are reaction coefficients. Theoretically the above specification can be estimated by use of ordinary least squares. In practice, several difficulties are likely to arise. Theory does not generally indicate the length of the lag which should be specified. Because of this, the statistical significance of the reaction coefficients are often analyzed for an indication of when to stop adding lagged variables. But if the lag length is very long, the addition of lagged terms will quickly begin to create a degrees of freedom constraint. Secondly, the lagged values of the P's will likely be highly correlated from period to period leading to imprecise estimates of the reaction coefficients when more than one lagged P is used.

These difficulties have led to the practice of imposing a priori assumptions or restrictions about the form of the reaction coefficient relationships or patterns. These restrictions reduce the number of parameters to be estimated, thus saving degrees of freedom and eliminating the need for a number of highly correlated independent variables. The restrictions imposed have generally been of two types - "one resulting from the requirements that the values of the B's should decline in a geometric progression and the other from the requirement that the value of the B's should first increase and then decrease."[1]

The most widely used assumption about the nature of the lag structure is that it should decline in a geometric pattern. The geometric lag distribution model has been rationalized in two different ways. Each rationalization leads to the same regression equation, but each has a different implication for the behavior of the regression disturbance. The two rationalizations for using a geometric lag distribution are generally known as the "adaptive expectation model" and "partial adjustment" or "habit persistence model."[2]

The specification derived from these two model's "partial adjustment" and "adaptive expectation" has the advantage of being easy to estimate. However, the use of a lagged dependent variable in the estimation procedure raises some difficulty with respect to detecting serial correlation and if serial correlation exists it will bias the

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[1]Jan Kmenta, Elements of Econometrics, (New York: The Macmillan Company, 1971), p. 474.

[2]Kmenta describes the procedure for specifying and estimating these models on pages 474-478.

parameter estimates. The primary objection raised to the use of the geometric lag models in this study and others rests in the restrictive nature of the lag shape or pattern obtainable. More precisely, it is often desired that the lag structure be capable of rising for a number of periods and then beginning to decline. (This capability is desired because of our knowledge of the technical, institutional and subjective factors affecting the distributed lag.) Such a distribution of reaction coefficients is generally termed as an "inverted V-lag distribution." Several techniques exist for estimating such lag structures, each involving some a priori assumption about the relation of the reaction coefficients. One approach is to use the "Pascal lag distribution."[1] While various formulations of the Pascal lag distribution model can be specified and estimated in principle, the practical complexity of their estimation (at least as compared to geometrics lag models) has led to a search for simpler formulations. One such technique is provided if one is willing to use the general inverted V-lag distribution and a priori specify the period in which the "V-lag" reaches a peak. The estimation form of such a model would appear as follows where the lag structure is assumed to peak at t - h.

$$Y_t = Q' + b_0'X_t + b_1'X_{t-1} + \ldots + b_h'X_{t-h} + c'Y_{t-1} + U_t \qquad (11)$$

The parameters of the specification have special significance due to the mathematical derivation of this estimable form.[2] This formulation

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[1] D.W. Jorgenson, "Rational Distributed Lag Functions," Econometrics, 34 (January, 1966), pp. 135-149.

[2] Kmenta discusses these interpretations and model derivations on page 491 of his text Elements of Econometrics.

has the advantage that estimation can be carried out in the same manner as the geometric model's estimation. The lag structure rises in a pattern dictated by the parameters until the peak period is reached and then takes on a geometrically declining pattern. However, if the peak reaction is a number of periods back this model begins to suffer the same problems as the general distributed lag model. That is, degrees of freedom are rapidly expended and high inter-correlation is likely to exist among the lagged dependent variables.

A different formulation of the inverted V-lag model has been developed by Shirley Almon.[1] Almon's specification requires one to assume that the reaction coefficients follow a smooth polynomial of a given degree; hence the common name, "polynomial lag model," is given to Almon's technique.

Specification of the polynomial lag model requires a priori determination of the degree of the polynomial and length of the lag (where length is essentially defined as the number of periods before the reaction coefficients will become zero). These two pieces of a priori information can be incorporated in a manner that allows a wider range of lag structures to be obtained than is the case with the geometric or various forms of the Pascal lag distribution.

Estimation of a polynomial lag model requires forming a number of "weighted variables" according to a formula derived from the a priori selection of the degree of the polynomial and number of

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[1]Shirley Almon, "The Distributed Lag Between Capital Appropriations and Expenditures," Econometrics. 33 (January, 1965), pp. 178-196.

periods in the lag.[1] Other a priori conditions can readily be injected into the lag structure if desired. For example, the lag structure can be forced to pass through the zero axis at certain periods. In general, specification of a high degree polynomial with no additional conditions imposed allows the greater flexibility in the estimated lag distribution.

Recent examinations of polynomial lag models have indicated that statistical criteria for selecting the polynomial degree and lag length which will lead to unbiased distributed lag estimates are presently not available.[2] Because of this, the approach taken in this study has been to select the degree and length of the polynomial lag according to knowledge of industry as opposed to using statistical criteria. In addition, constraints have been used which require the distributed lag pattern to pass through zero in the first and last period of the lag. These two zero constraints are based on the argument that no significant simultaneous or single period response in output generally occurs in livestock production and likewise, after a specified time period, a given stimulus no longer affects production.

In general, polynomial lags have been used here in modeling livestock supply response. The polynomial lag model was chosen because an inverted V-lag model was desired. In addition, a model was

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[1] J. Johnston, Econometric Methods, 2nd Edition (New York: McGraw-Hill Book Company, 1972), pp. 292-298.

[2] P. Frost, "Some Properties of the Almon Lag Technique When One Searches for Degree of Polynomial and Lag." Journal of the American Statistical Association, 70 (1975), pp. 606-612.

desired which was capable of generating lag structures of an independent nature for each of several independent variables in the supply relation. A polynomial lag model is capable of doing this without a great deal of practical difficulty.

Geometric lag models were chosen elsewhere in the model because knowledge of the technical, institutional and subjective factors affecting the lag structure were felt to indicate this form of lag pattern.

The rationale for an inverted V-lag structure for livestock supply response is discussed by Trapp.[1] Briefly, the discussion is as follows for the case of meat producing animals such as beef cattle or hogs. The initial reaction of producers to an increase in output prices is to feed to heavier weights to adjust the new and higher marginal value product function to marginal cost. This causes a positive output response. As the change in product price is perceived to be more permanent the opportunity cost relation between holding female stock for breeding purposes versus selling them for slaughter is altered. Producers will consider this change and make adjustments in breeding herd replacement and culling rates in an attempt to approximately maximize the net present value of expected revenue flows. In the case of an increase in output prices, this adjustment results in a negative slaughter response as more female stock are retained for breeding purposes rather than slaughtered. Eventually,

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[1]James N. Trapp, "A Polynomial Distributed Lag Model of Pork Production Response," Department of Agricultural Economics Staff Paper #75-29. East Lansing: Michigan State University, 1975.

as the retained breeding stock begin to produce increased numbers of slaughter animals, substantial increase in product output will occur. Figure III.5 shows the lag distribution pattern hypothesized from the preceding rationale. The rate and magnitude of the response to the factors creating this lag shape will depend on the size of the price change; the lag in recognizing that a price change has occurred; biological constraints specific to the animal type in question, the current asset investment situation and production practices of producers. As alluded to previously, technical, institutional and subjective factors all affect the nature of the composite or aggregate lag structure.

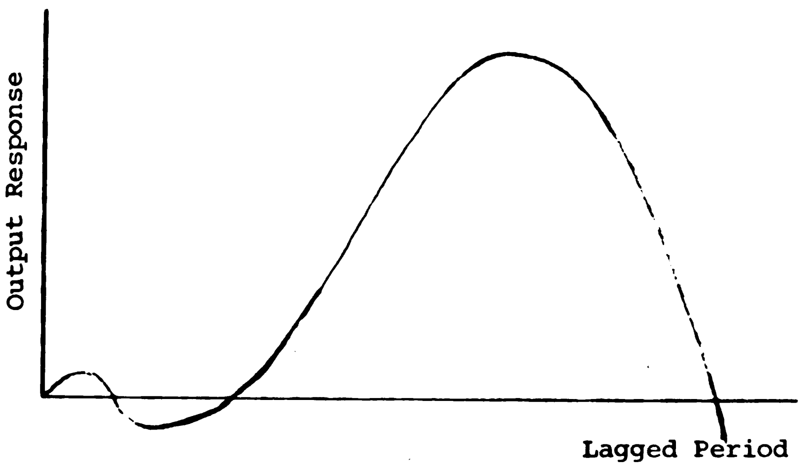

Figure III.5 Hypothesized distributed lag structure for livestock supply

A similar argument could be developed for the response of producers to an input price change. Their initial reaction would be to feed to lower weights. This would be followed by increases in culling and the withholding of fewer female replacement animals. The response pattern would thus be the inverse of Figure III.5.

Demand

Demand functions specified in the NASS model fall into several basic types including derived demands, direct demands, stock demand and export demand. The theory of each of these demand types and the basis for making these distinctions will be discussed in this section.

Derived Demand

The theory and reasoning for derived demand specifications has been discussed in conjunction with specification of livestock supply response functions. Derived demand functions are specified for feed-grain, high protein feed, land or acreage planted and seed.

Seed demand and land demand are derived input demands for crop producing activities. The nature of the static derived demand specification for land is given in relation (9). The static derived seed demand relation is theoretically of the same form. Seed input demand can alternatively be treated as a perfect compliment to land input. Basically seeding rates per acre are very stable with small alterations due to technological changes in planting techniques and seed varieties occurring over time. Hence, the decision to plant an acre of land includes the decision to use the complimentary set of seed involved in this process. The approach taken here is to determine the technical ratio between acres planted and seed use, and to determine seed use from the acreage response estimates. This procedure may be valid for determining other input demands in the crop sector if two conditions hold -- first, the input is nearly a perfect compliment to land; and second, the impact of the cost of this input (if indeed its cost has any significant measurable impact) is taken into consideration in estimating the acreage response function. This model in its present form has not attempted to derive any other crop input demands such as machinery use, labor use, etc. by this approach.

Direct Demand for Grains

The second type of demand relation specified is demand for human consumption. Presently direct demand for human consumption is specified at the farm level. The problem of modeling "farm to retail" price spreads has not been addressed to date.[1]

The theory useful in specification of consumer demand functions is similar to micro firm theory. Consumers attempt to maximize a cardinal utility function as opposed to producers attempting to maximize an ordinal objective or profit function. Consumer utility maximization is constrained by income while firm profit maximization is constrained by fixed asset availability and production relations. The general consumer utility function for n commodities can be written as follows:

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[1]One approach to modeling the farm-retail price spread is to view farm products as inputs in the production of processed foods and marketing services. This essentially specifies farm level demand as a derived demand and retail demand as a direct demand. Proper specification of a system of equations using this approach will allow a solution for the system to be obtained which will provide estimates of both farm level and retail level prices. Hence, indirectly a farm-retail price spread will be obtained. Dissertation work by Shirley Pryor (unpublished Michigan State University Ph.D. dissertation) will provide empirical estimates of such a system for a number of commodity categories in the NASS model. These estimates are capable of being linked to the NASS model structure. In addition, Pryor is considering the impact of various consumer policies upon demand for food at the retail level. The retail level policy impacts could be traced to the farm level by an integration of the NASS model with Pryor's work.

(12) $V = f(q_1, q_2 \ldots q_n)$

and his budget constraint as

(13) $Y - \sum_{i=1}^{n} p_i q_i = 0$

where

V - Consumer utility

Y - Consumer income

p_i - Price of the ith product consumed

q_i - Quantity of the ith product consumed

The Lagrangian function given the two previous relations is formed as follows:

(14) $\Pi = f(q_1 q_2 \ldots q_n) + \lambda(Y - \sum_{i=1}^{n} p_i q_i)$

Assuming that utility can be measured in an ordinal sense, the mathematical conditions for maximizing utility requires that the set of partial derivatives of the Lagrangian function equal zero. This requirement states that the ratio of marginal utility and price of each product be equal and that the budget constraint be satisfied. The $n + 1$ partial derivatives can be solved for the n q's and hence, the theoretical direct demand function is determined. It would appear as follows:

(15) $Q_i = f(P_i, P_j, Y) \quad j \neq 1 \text{ and } 1 \leq j \leq n$

<u>Demand for Livestock Products</u>

Consumer demand functions appear in the NASS model for food grains, livestock products and feedgrains used in making processed foods and beverages. The assumption made about the competing demand relations in the crop markets as opposed to the livestock product market lead to a different specification of the direct demand relations in these markets. In the case of crops several sources of competing demand are assumed to exist. Also the grain produced in a given year does not have to be consumed but may be stored. It is assumed that direct demand of livestock products for human consumption is the only source of demand and that no livestock products are stored from year to year. Therefore, livestock consumption in a given year is assumed equal to production. Since livestock production is recursively determined (that is, only lagged endogenous and/or other exogenous variables are used to estimate current livestock slaughter), price and quantity can be solved in a two-step procedure. Quantity is determined first and then used in the demand relationship to determine price. The typical livestock price dependent demand function would appear as follows:

(16) $$P_{LIV} = f(Q_{LIV}, Q_{SUB_i}, Y)$$

where

P_{LIV} - Farm level price of livestock

Q_{LIV} - Per capita production of the livestock product

Q_{SUB_i} - Per capita production of one or more substitute livestock product

Y - Per capita deflated disposable income

In the case of crops the quantity supplied is recursively determined. Since several demands compete simultaneously to determine the price and allocation of the fixed supply among the different sources of demand, demand equations are specified as quantity dependent and must be solved simultaneously.

The preceding description of the livestock and crop supply and demand interfaces and assumptions made in specifying these interfaces empirically point out several simplifications used to approximate the real world, and possibly some weaknesses in the model. One of the most glaring weaknesses is perhaps the lack of any mechanism to allow livestock producers to react to current period endogenous factors and adjust livestock production by changing marketing weights of animals or slowing versus hastening marketing dates. The assumption of production equaling consumption in the case of livestock products may also overlook to some extent the ability to store frozen meat and manufactured dairy products.

Stock Demand

The theory of stock demand is poorly developed and controversial in nature. Two basic arguments exist concerning stocks; one is that stocks are essentially a residual of other forces and the other, that specific motives exist for demanding stocks. The latter position will be argued here.

This model considers stock and/or inventory demand in two general cases. The first case is that of livestock breeding herds which can be viewed as a demand for accumulating inventories or stocks of inputs into the livestock production process. The second is that of grain stock demand. The following remarks are directed toward the method used in estimating grain stock demand but may have some relevance in livestock inventory demand.

The grain model is structured so that a "market clearing" price is determined by solving a set of simultaneous equations (one of which is an identity stating that supply must equal demand plus the change in stock holdings). Evans[1] discusses several motives for holding stocks including: 1) transactions demand or what may be referred to as "pipe line" stocks whose existence is created by processing lags, goods in transit, discrete delivery dates, order sizes etc.; 2) buffer stocks -- these are stocks held to smooth out operations when sales or production (input supply availability) are improperly forecast; 3) speculative demand -- speculative demand may occur for two reasons: The most commonly considered motive is for creating speculative profit by buying low and selling high. Firms may also speculate by buying large stocks before expected price rises, or depleting stocks to low levels before expected price falls; 4) backlog of demand -- if manufacturing firms are shipping goods at a certain rate, but their backlog of orders is high, they will stock more inventories in response to this established demand.

Evans concludes his discussion of motives for stock demand by stating:

> Many discussions of inventory investment hinge on explanations of expectation and errors in forecasts. Although we argue that these are important, the expectations and errors are made with respect to sales and prices within the framework of the above categories.[2]

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[1] Michael K. Evans, Macro Economic Activity: Theory, Forecasting and Control, (New York: Harper & Row, Publishers, 1969).

[2] Ibid., p. 204.

Attempts to quantify expectation levels and adjustments made to compensate for improper forecast or expectation have met with only limited success historically. The major theories considered here that have attempted to quantify expectation formation and stock adjustment are the "partial adjustment" model (sometimes referred to as the stock adjustment model) and the "adaptive expectation" model. These two models and the joining of them into one "compound geometric lag" model are discussed by Kmenta.[1] It is the assumption of each of these models and the joint consideration of them from which the basic methodology underlying the specification of grain stock demand is obtained.

Private Grain Stock Demand

Demand for grain stock is divided into two parts; government demand and private demand. This distinction is made because the motives for holding stocks vary between the two sources. The following assumptions concerning expectation and adjustment are made with regard to the private stock demand:

(17) $$Stk^{*} = a_0 + b_0 P^{*}_{t+1} + b_1 Con_t + b_2 GStk$$

(18) $$\Delta Stk = k(Stk^{*} - Stk_{t-1})$$

Verbally, relation (17) assumes that desired carryout stocks (Stk^{*}) are a function of prices expected the following year (P^{*}_{t+1}), domestic consumption levels of the grain (Con_t), which are assumed to proxy the amount of transactions stocks needed, and government holdings

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[1]Kmenta, Elements of Econometrics, section 11-4.

of stocks (GStk). Government holdings of stocks are interpreted as reducing the need for buffer stocks held by private firms as a hedge against crop shortages or large export demands. Relation (18) states that complete adjustment of stocks to desired levels cannot occur in a single year, hence k is the "adjustment coefficient." Substituting (17) into (18) and decomposing the ΔStk term yields the following relation:

(19) $$Stk = ka_0 + kb_0P^*_{t+1} + kb_1Con_t + kb_2GStk_t - (k + 1)Stk_{t-1}$$

The expectation model for P^*_{t+1} remains to be developed at this point. The "naive" assumption generally made in the literature is that of the "adaptive expectation" model. This model is based on the idea that the current expectations are derived by modifying previous expectations in light of the current experience. Therefore, P^*_{t+1} is assumed to be formed in the following manner:[1]

(20) $$P^*_{t+1} - P^*_t = (1 - \lambda)(P_t - P^*_t)$$

where $0 < \lambda < 1$

Relation (20) can be rewritten as follows:

(21) $$P^*_{t+1} = (1 - \lambda)(P_t + \lambda P_{t-1} + \lambda^2 P_{t-2} +\dots \lambda^n P_{t-n})$$

This form is readily substitutable into expression (19) to obtain the following relation:

(22) $$Stk = ka_0 + kb_0[(1-\lambda)(P_t + \lambda P_{t-1} + \lambda^2 P_{t-2} +\dots+ \lambda^n P_{t-n})] + kb_1Con_t + kb_2GStk_t - (k + 1)Stk_{t-1}$$

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[1]Note that the expectation adjustment postulated here is slightly different from the standard textbook specification in that the adjustment of expectations for next year is a function of the error in expectation this year.

This, however, presents an unworkable specification in regard to estimation; hence the "Kyoch transformation" is applied in order to obtain the following theoretical relation for estimation:

$$(23)\quad Stk = (1-\lambda)ka_0 + kb_0(1-\lambda)P_t + kb_1(Con_t-\lambda Con_{t-1})$$
$$+ kb_2(GStk_t-\lambda GStk_{t-1}) - (k+1+\lambda)Stk_{t-1}-\lambda(k+1)Stk_{t-2}$$

or collapsing the constants of (23) to get the following general form:

$$(24)\quad Stk = a_0' + b_0'P_t + b_1'Con_t + b_2'Con_{t-1} + b_3'GStk_t + b_4'GStk_{t-1}$$
$$+ b_5'Stk_{t-1} - b_6'Stk_{t-2}$$

It can be argued quite strongly that private stock holders have much more information at hand and use a more sophisticated expectation model than the "partial adjustment" model. During, and indeed, at the end of the crop year, much is known about the new crop for which the harvest is just beginning and about foreign and domestic market conditions. One could postulate that at a minimum the stockholder would know at some point during the current crop year the acres planted and the support price for next year's crop and that his expectations of P^*_{t+1} would be influenced by these factors, i.e.:

$$(25)\quad P^*_{t+1} = a_0 + b_0\ AP_{t+1} + b_1\ SP_{t+1}$$

Hence, if this relation were substituted into relation (19) for P^*_{t+1} the following theoretical function would result:

$$(26)\quad Stk = ka_0 + kb_0(a_0 + b_0AP_{t+1} + b_1SP_{t+1}) + kb_1Con_t + kb_2GStk_t$$
$$- (k + 1)Stk_{t-1}$$

or in general form with the constant terms collapsed:

(27) $Stk = a'_0 + b_0 AP_{t+1} + b_1 SP_{t+1} + b_2 Con_t + b_3 GStk_t + b_4 Stk_{t-1}$

These two basic assumptions concerning the nature of the formation of P^*_{t+1} have been explored in function estimation attempts for private stocks. The results and alterations from the theoretical base presented here are discussed in Appendix C-5. In general the specifications implied by the preceding theoretical derivations did not produce statistically robust private grain stock models.

Government Grain Stock Demand

Desired stocks held by the government are felt to be a function of the price level the government wishes to support and its policy decisions concerning food aid, both domestic and foreign.

(28) $GStk^* = a_0 + b_1 (P_t - SP_t) + b_2 \text{ P.L.480} + b_3 \Delta CPI$

Essentially desired government stocks are policy determined and as such, relation (28) attempts to proxy policy directives and/or forces which create policy directives. In an economic model such forces might perhaps best be modeled as exogenous. The option chosen here, however, is to attempt to model the policy determination as specified in relation (28) where government actions to support prices are captured by the difference between the market price (P_t) for grain and the support price (SP_t) for the grain. Foreign food aid policies are proxied by the level of P.L. 480 shipments. Political pressures to carry out domestic food distribution programs are proxied by the general inflation rate, the rationale is that high prices will in general bring forth pressures to provide basic welfare to all people, particularly food aid. These proxies of foreign and domestic food aid are nebulous with regard to signs, for in order to carry on such aid programs the government must obtain grains in some manner. These activities are thus associated with "drains" as well as "additions" to government inventory. Realistically one should perhaps attempt to model desired purchases by the government and desired sales by the government, since the two motives are not the inverse of each other, but are driven by different factors. Such an effort is beyond the scope of this project.

Having specified the desired stocks the government wishes to hold, the question remains as to whether the government actually achieves its desired stock level, or empirically is k in the following relation equal to one.

$$(29) \qquad \Delta GStk = k(GStk^{*} - GStk_{t-1})$$

Several intuitive arguments would indicate that the government is subject to several institutional constraints on fulfilling its desires; i.e., because of internatinal politics it cannot dump on the world market to the extent it may have desired; domestic politics have prevented the suppressing of domestic prices for grains by domestic selling of government stocks in the open market, etc.

Substituting (28) into (29) and decomposing the ΔGStk term yields the following theoretical relation to be estimated:

$$(30) \quad GStk = ka_0 + kb_1(P_t - SP_t) + kb_2P.L.480 + kb_3\Delta CPI - (k+1)GStk_{t-1}$$

or reducing the constant terms

$$(31) \qquad GStk = a_0' + b_1'(P_t - SP_t) + b_2'P.L.480 + b_3'\Delta CPI + b_4'GStk_{t-1}$$

The preceding theoretical relations can be altered in order to delete the policy proxies for domestic and foreign food aid motives by dropping the P.L. 480 and ΔCPI terms. Appendix C-5 contains a discussion of the problems encountered in estimating the above theoretical government stock models.

In summary, the discussion of methodology used in specifying grain stock functions for the NASS model is not strongly grounded in economic theory since little theory concerning stocks exists. The methodology draws heavily upon basic assumptions made about expectations and adjustment processes and the "convenient" empirical techniques used to describe these assumptions.

Grain Export Demand[1]

The approach taken to estimating U.S. grain exports involves an indirect three-step process. First, total grain import demand for each of 19 countries or regions is estimated using an excess demand function. Second, grain imports from the U.S. for each of these regions or countries is estimated using the total grain imports as one of the explanatory variables. Third, the estimates of U.S. grain imports by each region are summed to determine a total U.S. grain export estimate.

Theoretical Considerations

The basic theory underlying the specification of the import equation for any region or country considered in the model is

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[1] The author was involved in the development of the original theory and price linkage concepts used. The actual estimation and development of modifications to the theory to be described here were carried out by Dr. Vernon Sorenson and Dr. Susumu Hondai.

developed from the one-commodity, two-country world, equilibrium model. Such a model is graphically depicted and described below.

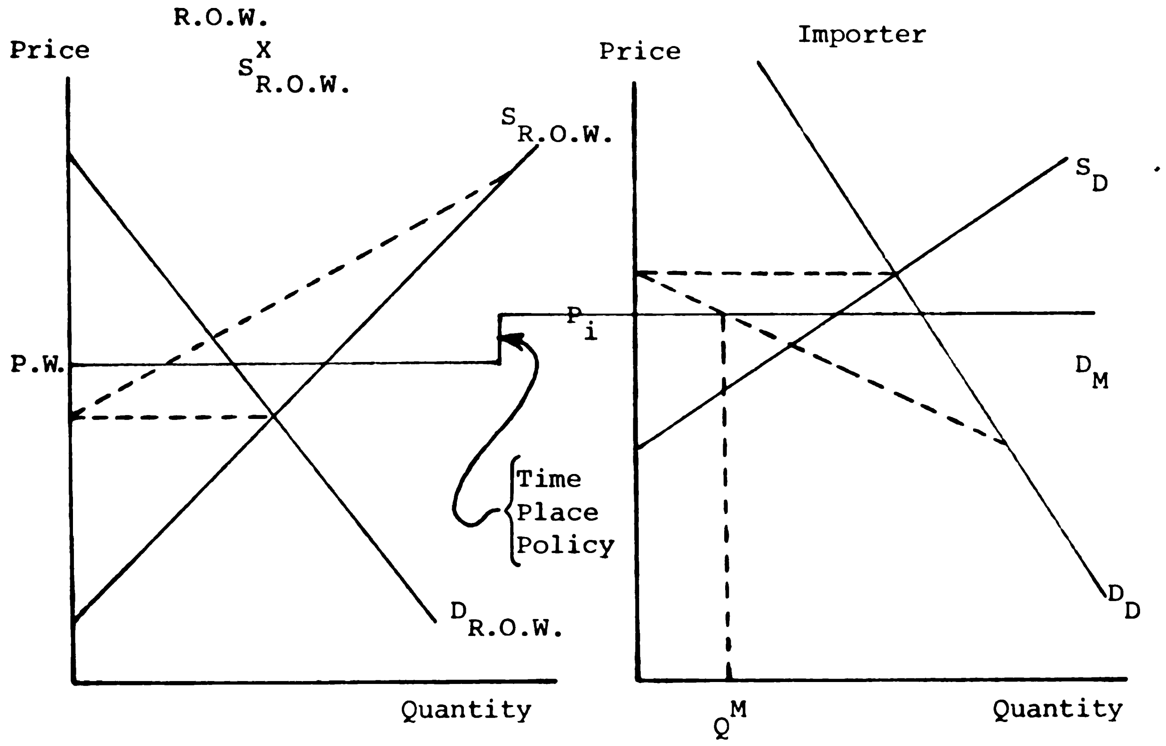

Figure III.6 One-commodity, two-country world, equilibrium model

where

$R.O.W.$ - Rest of the world which in this case is a net exporter

$S_{R.O.W.}$ - Domestic Supply of R.O.W.

$D_{R.O.W.}$ - Domestic demand of R.O.W.

$S^X_{R.O.W.}$ - Export supply of R.O.W.

P.W. - F.O.B. export price of R.O.W.

S_D - Domestic supply of the importer

D_D - Domestic demand of the importer

D_M - Import demand of the importer

Q_M - Quantity imported

P_i - Domestic price of the importer

P_i-P_W - Price differential due to time, place, form and policy effects

For the purposes of the NASS model an estimate of Q_M is desired for each importing country of the world. Ideally, in determining this set of Q_M values, one would consider the nature of supply and demand interactions in all exporting and importing countries of the world. In this manner all trade flows would be considered and a world equilibrium system could be developed with a market clearing and price formation mechanism. This is beyond the scope of this analysis. The major interest of this effort is to estimate U.S. exports through a partial equilibrium system which is linked to an unidentified (unmodeled) total equilibrium system. This is achieved by several simplifying assumptions.

In determining a country's total imports of a given grain, the world price, or more specifically, the import price of the grain is considered to be exogenous. (The import price of a given grain in a given country is, however, linked to the U.S. domestic price for the grain and hence not exogenous to the total model.) Given the import price (P_i in Figure III.6), the import country's supply and demand relations determine the import level in a free market.

The trade component does not attempt to model importing nations' supply and demand, but rather proceeds to specify a single function estimating the quantity of imports. The theoretical base of this function is the excess demand equation which is based on the difference between demand and supply at a given price, that is:

(32) $$Q_S = f(P, X_1)$$

(33) $$Q_D = f(P, X_2)$$

(34) $$ED = Q_D - Q_S = f(P, X_1, X_2)$$

where

Q_S - Quantity supplied

Q_D - Quantity demanded

ED - Excess demand

P - Price

X_1 - A set of factors shifting domestic supply

X_2 - A set of factors shifting domestic demand

Following the specification of relation (34) the model estimates imports as a function of price, supply shifters and demand shifters. In general a single proxy is used to represent the impact of all demand shifters. For developed countries this proxy is total income while in less developed countries the proxy used is population. Production of the import commodity in question is entered directly as a proxy of supply shifters.

The model only partially takes account of the impacts of tariffs, quotas, minimum import prices, variable levies, price support programs etc. in the importing country. The nature of these restrictions are broad and difficult to quantify and entail rather involved analysis to be dealt with directly. It is, therefore, assumed that these restrictions, when altered, will result in changes in a country's production level and thus can be proxied by changes in the year to year production level in the importing country.

The above general model and subsequent simplifying assumptions lead to the following general specification for a total import demand function of a given region.

(35) $$M_i = f(P_W, Q_t, Q_{t-1}, Y)$$

where

M_i - Total regional imports of a given commodity

P_W - Implicit regional import price, i.e., total value of imports divided by total quantity of imports

Q_t, Q_{t-1} - Domestic production of the commodity by the importer in period t and t-1

Y - Gross domestic product[1]

Given an estimate of total imports, the next step is to determine imports from the U.S. which is done by the following general specification:

(36) $$MUS_i = f(P_{US}, P_C, M)$$

where

MUS_i - Regional imports from the U.S. of a given commodity

M - Total regional imports of a given commodity

P_{US} - Implicit regional import price (delivered price) from the U.S.

P_C - Implied regional import price (delivered price) from competing exporters

The above specification makes the estimated quantity of imports from the U.S. responsive to the competitive price between the U.S. and other exporters. Summation of all regional imports from the U.S. provides an estimate of total U.S. grain exports.

The preceding theory and simplifying assumptions generate the basic specification used to model import demand and specific demand

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[1]In the case of less developed nations, population is generally used as a variable in place of gross domestic product.

for U.S. commodities in the world market. Further modifications are made with respect to the preceding specification in the case of less developed countries. First, grains are not divided into foodgrains and feedgrains, but rather one aggregate grain import is considered which, in most cases, consists largely of food grains or other grains used for human consumption. Second, less developed countries are generally aggregated in large regions, namely the following four -- 1) South and Southeast Asia, 2) Mideast and North Africa, 3) Sub-Sahara Africa and 4) Latin America. Developed countries tend to be treated pretty much in single-country or two-country regions. These include Belgium-Luxembourg, France, Germany, Italy, Netherlands, Japan, United Kingdom, Canada, Austria, Switzerland, Norway, Portugal and Spain, Denmark and Ireland, Greece and Yugoslavia, Finland and Sweden.

The aggregation of LDC's into large regions and data problems lead to a different approach to determining U.S. grain exports to a given LDC region. Regional LCD distinctions were attempted to be made on a basis of homogenous country characteristics. The countries included in estimating total import demand for a given LDC region, are limited to those for which data could be obtained. Estimates of imports from the U.S., however, are for the entire region. The total grain import estimated for selected countries in each region are summed and included as a factor in determining U.S. grain exports to the entire region. Hence, the specification is as follows:

(37) $$M_i = f(P_W, Q_t, Q_{t-1}, \text{Pop})$$

(38) $$MUS = f(P_W, \sum_{i=1}^{n} M_i, \text{P.L.480})$$

where

M_i - Total grain imports into sub-region i

P_W - Average implicit import prices of grains from all sources to all countries in sub-region i

Q_t, Q_{t-1} - Total production of all grains in all countries of the sub-region in period t and t-1

Pop - Total population of all countries in the sub-region

M_{US} - Total U.S. exports to the region

P.L.480 - Public Law 480 exports from the U.S. to the region

It should be noted that the functional specification for regional imports from the U.S. contains no competitive price factor. Instead, the average implicit import price is used. This price is in turn linked to U.S. foodgrain prices.

It becomes necessary for purposes of operation of the domestic crop price determination mechanism to divide LDC total grain imports from the U.S. into foodgrain (wheat) and feedgrain (corn, oats, barley and sorghum) components. This is done by the following relation:

(39) MWHTLDC = f(MUS, T)

where

MWHTLDC - Imports of wheat from the U.S. by LDCs

MUS - Total grain imports from the U.S. by LDCs

T - Time

Estimates for foodgrain and feedgrain imports from the U.S. are made in the preceding described manner for 19 regions. The regions comprise nearly all of the U.S. export demand of feedgrains, foodgrains and soybeans, with the exception of those to Communist bloc countries. Attempts were made to use a similar approach to estimate Communist bloc imports. Only limited success was achieved, hence it was decided to specify Communist bloc demand for U.S. grains as exogenous. Communist bloc grain demand and other minor residual grain demand (also exogenous) are added to the sum of estimated demands for U.S. grain exports in order to get an estimate of total demand for U.S. grain exports, i.e.,

(40) $$\text{Total U.S. exports} = \sum_{i=1}^{19} M_{US} + \text{Residual Exports}$$

Price Linkage Mechanism

Three international market prices or price concepts are required in the preceding specifications; 1) an implicit delivered price of U.S. export commodities (P_{US}); 2) an equivalent average price for competing exporters (P_C), and 3) a general implicit import price (P_W) for imports from all sources by a given importing country. These prices are intended to reflect the competitive situation in the world grain market and provide a link between the U.S. domestic market for grains and the international market for grains.

Links between U.S. domestic prices and four forms of export commodity prices are formed. Each link is slightly different because of the competitive nature of the partial equilibrium being modeled. In the case of feedgrain and wheat exports to developed countries, the linkage is formed as follows:

(41) $$P_X = f(PRBF, PROD, STK, \overline{SUPP})$$

(42) $$P_{US} = f(P_X, \overline{WAGE})$$

(43) $$P_C = f(P_X, \overline{X}_1)$$

(44) $P_W = f(P_X, \overline{X}_2)$

where

P_X - U.S. Gulf Port export price of the commodity

P_{US} - U.S. implicit import price (delivered price)

P_C - Implicit import price (delivered price) of competitors

PRBF - Price received by U.S. farmers

PROD - U.S. production

STK - U.S. stocks

SUPP - U.S. supported price

WAGE - U.S. non-agricultural wage rate

X_1 - A set of factors affecting competing exporter export supplies

X_2 - A set of factors reflecting U.S. world price spreads

This linkage system forces all world prices to move proportionately to the U.S. export price, and in turn, to the domestic price received by farmers when exogenous variables proxying the competitive situation in the world market are held constant.[1]

In the case of LDC grain imports, no distinction is made between food grains (wheat and rice) and feedgrains (corn, oats, barley, sorghum and others). Rather, grain imports are treated as one class which consist mostly of foodgrains, primarily wheat. No competitive price mechanism was considered for LDCs. Therefore, in the case of LDCs, U.S. Gulf Port wheat export price is linked directly to an average implicit import price for all grains from all sources. This

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[1]In actual estimation most proxy variables attempted to represent X_1 and X_2 were found to have weak statistical significance.

price is the only price entering the LDC grain import functions.

In the case of soybean exports a different world market situation was assumed than was the case with feedgrains and foodgrains. The influence of competing exporters on U.S. export markets for soybeans is weak.[1] Therefore, no price link was established between U.S. prices and competing export prices. Secondly, the U.S. domestic market and export activities for soybeans have been subject to very little direct price control or export regulation. For these reasons foreign demand for U.S. soybeans is estimated directly as follows:

(56) $MUS = f(P_{US}\ \bar{X}_1\ \bar{X}_2)$

where

MUS - Quantity of soybean meal equivalents imported from the U.S. by country X

P_{US} - Price of 44 percent soybean meal at Decatur, Ill.[2]

X_1 - Factors influencing demand for soybean meal in the importing country (income)

X_2 - Factors influencing supply of soybean meal in the importing country (production)

This specification does not require any domestic international price linkage.

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[1]The recent increase in Brazilian soybean production and exports may require modifications to be made in this respect.

[2]Soybean and soybean meal prices are linked functionally in the model. Soymeal price is a function of soybean price, soy oil price, wage rates and time. Soybean prices are endogenous to the model while soy oil prices and wage rates are exogenous. The wage rate variable is intended to proxy changes in processing cost while the time factor picks up technical improvements in soybean processing.

Schematically, the price linkages established can be summarized as illustrated in Figure III.7.

Model Computerization

In dealing with a model of large size (this model contains 249 functional relations and identities and over 300 aggregative final form data series) it is necessary to computerize the empirical relations and linkages comprising the model. Several elements must then be taken into account: 1) what solution algorithm will be required and can be used; 2) what options and model "management features" are desired in the model; 3) what output forms are desired; and 4) what is the cost of developing the computer program and subsequent cost per run.

Solution Procedures

The solution procedure must be compatible with the model's structure and estimating techniques. If the model is entirely recursive and has discrete time periods, then a step-by-step mathematical solution procedure can be used. This is the simplest solution procedure to computerize and is used in certain portions of this model. The programming procedure must keep the step-by-step flow of estimates and information correct and maintain a proper time subscript on the variables. Problems of linear versus non-linear functions are of no consequence.

On the other hand, if the model has simultaneous relations a simultaneous solution algorithm is required. The nature of this algorithm is dependent upon whether the functional relations are

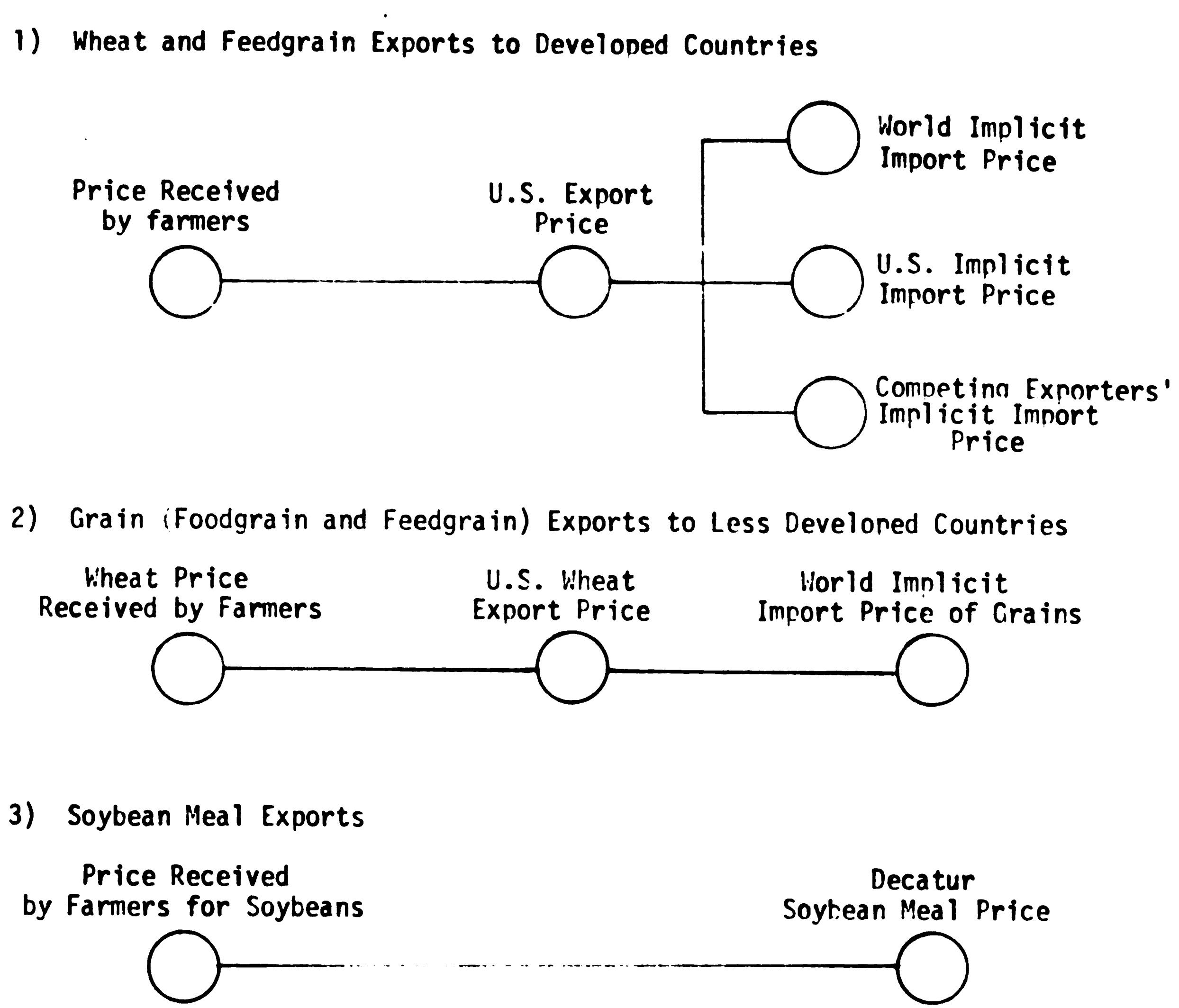

Figure III.7. Price linkage structures

linear or nonlinear. If linear functions are involved, as is largely the case with the model in question, matrix algebra can be used to solve the system. A second solution alternative would be to use any of a number of linear programming solution techniques. This modeling effort has chosen to use matrix algebra procedures and established computer subroutines to perform the matrix inversion and multiplication processes involved.

This solution process is cheaper than many other linear and nonlinear routines because the matrix inversion step is only required once if the results of the process are stored and no changes are made in parameters. Hence, each solution procedure involves only a matrix multiplication process.

The specification of a linear model and solution process limits one's capabilities to consider relations which are nonlinear. Various procedures can be used to inject nonlinear behavior into a linear model; separable programming as used in linear programming is one example. The approach taken in this model is to place nonlinear constraints on values which fall at the extreme range of functional relations and are felt to have strong nonlinear properties. The most important of these is in predicting grain stocks. Government purchases are forced to divert from the linear solution value if market price drops significantly below the support price. In addition, government and private stocks are not allowed to drop below some minimum percentage of consumption. The minimum stock level and market support price ratio allowed are exogenously set and can be specified by the user. Whenever a violation with respect to one of the stock constraints is

encountered the program first notes the violation by printing a message and then invokes a shifting factor on the stock function in question and repeats the solution process for a new solution. It repeats this process until the constraint is satisfied or a specified maximum number of attempts have been made to alleviate the constraint violation.

Management Features and Output Forms

A second factor to be considered are "options" and "model management features" one wishes to "build-in" to the model. Constraints and adjustments alluded to in the solution process can be included as one type of model management factor. "Model management," in a broader sense, deals with being able to inject certain sets of assumptions and scenarios of events upon the model. A capability to consider a broad set of assumptions and scenarios as well as an easily accessed method to inject these factors for consideration is desired. Another model management question arises with respect to the ease the model parameters can be altered when updated estimates of these values are available.

The NASS modeling effort has not as yet developed extensive computer software to perform such management tasks. However, the computerization efforts thus far have followed the guidelines of an "executive model management routine" developed at Michigan State University.[1] A key element in this approach is the need for large

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[1]Chris Wolf, Thomas J. Manetsch and Claudia Winer, "A FORTRAN Executive Program for Continuous Flow Simulation Models-SIMEX 1," Training Program Paper, East Lansing: Michigan State University, 1974.

models to be broken into independent sub-systems whenever possible. This aids model development and use in several ways:

1) It allows for the development and subsequent alteration of each sub-system independently. Alterations in the structure of one sub-system affect the rest of the model only if they affect the outputs of the sub-system which are used as inputs in other portions of the model.

2) It permits working with each sub-system independently of the rest of the model in debugging and validating the model. Also, in conducting analysis where questions specific to a subsector are being considered, the rest of the model can be "turned off" and disregarded. This is helpful in debugging the technical aspects of computer programming and in isolating sources of error.

3) It allows different time frames, solution techniques, constraint impositions, aggregation levels, "model management and display features" etc. to be used in each sub-system. Only the information passed between sub-systems must be compatible in definition, not the information and structure within each sub-system.

With respect to these guidelines for creating sub-systems the NASS model has been divided into three basic structural submodels; the crop supply sub-system, the livestock supply sub-system, and the demand sub-system. Several additional sub-system breakdowns are made on purely technical grounds to aid programming and the use of relatively standardized subroutines and programming procedures for creating lags, solving simultaneous systems of equations, etc. A number of subroutines also exist for conducting various "model management" options and for presenting tabular summations of the model's output. These subroutines include: 1) a subroutine which allows exogenous variables to be estimated or scenarioed in a variety of ways; 2) an information printing subroutine which prints model estimates, observed real values (when available), error in predicting these values, nominal values of deflated prices and a set of aggregate summary information including livestock feed consumption rates, total revenue from livestock sales, total crop revenue, total land in major crops, total cost of feed fed to livestock, per capita consumption of all meats, individual categories of meat and an estimate of gross farm income; 3) a constraint routine which can invoke any of a number of standard constraints based upon consistency checks such as the nonlinear constraints and adjustment described for stocks. Another option presently developed is a constraint requiring grain consumption per head of livestock to fall in a given range. In addition, the capability exists, at the user's discretion, to invoke "add" and/or "mul" factors upon any funtion in the model.[1] This option is intended for use in projections and forecast where it is believed that random or systematic impacts created by factors not considered

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[1] "Add" and "mul" factors are injected as follows where f(x) is the function involved

$$f'(x) = (f(x) + a)*m$$

where

- $f'(x)$ - Adjusted function
- $f(x)$ - Unadjusted function
- a - "Add" factor
- m - "Mul" factor

when $a = 0$ and $m = 1$, $f'(x) = f(x)$.

in the model will alter a particular activity or relation in the model. The use of any of these constraints is always noted in the program's output by messages describing the nature and magnitude of the constraint (or adjustment) imposed. An option selection mechanism exists which allows various subcomponents to be "turned off" and hence fed into the model as exogenous. A controllable option also allows for alteration of the time span in terms of starting and ending periods for which the model is run.

A flow chart diagram in Figure III.8 serves to illustrate the subroutines developed for use in solving and using the model. Essentially the flow of events carried out by the program includes: First, establishing all starting values, program options in effect, constraints to be considered, etc. Second, solving the various recursive and simultaneous elements of the model. Third, checking the constraint violations and making iterative adjustments. Fourth, printing a summary of the estimation results. Fifth, performing the proper lagging of endogenous values so as to maintain the proper feedback flows. This process is repeated for each year for which an estimate is desired.

If the model has been run over a historical period where comparisons of actual versus estimated values are possible, a set of statistical model performance or accuracy values is printed after the last solution iteration. A discussion of these values will be presented in Chapter V. They include a simple correlation coefficient of predicted regressed on actual values, several Theil U-coefficients, a mean squares error term, average bias figure, etc.

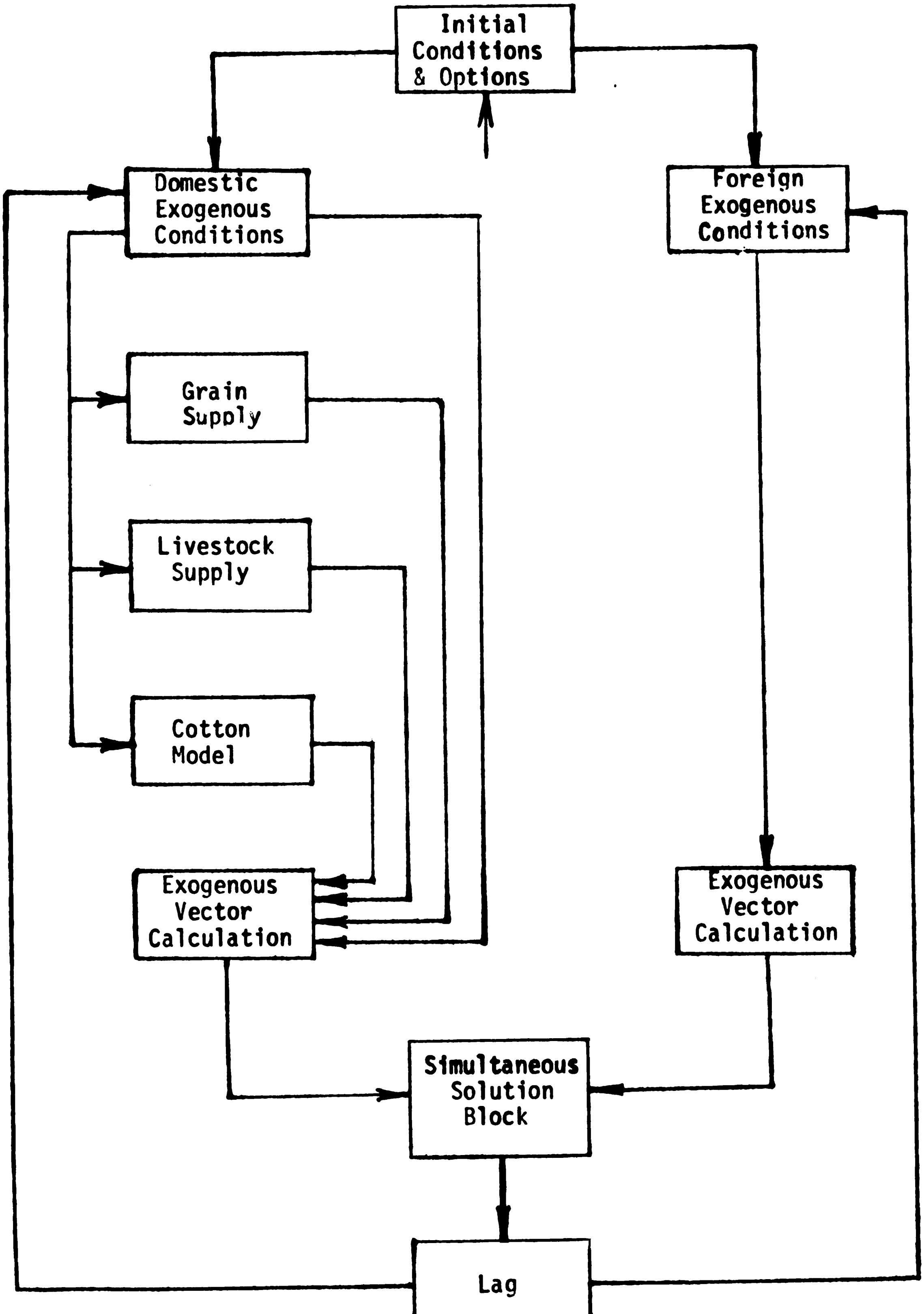

Figure III.8. Subroutine flow chart

The computer program is written in Fortran and uses relatively standard software; i.e., matrix operation subroutines, etc. and hence, should be readily adaptable to any computer. At present the program requires approximately 45 seconds of execution time to generate 10 years of forecasted values. The "core" requirement to execute the program is 47,100 bytes. Total running cost depends upon the rate charged for time, core use and printing at a given installation. The commercial rate on the Michigan State 6500 C.D.C. System presently is less than $10.00 and can be under $5.00 if low priority rates are used.

CHAPTER IV

ECONOMETRIC ESTIMATION RESULTS

Two hundred and forty nine equations using over 300 data series comprise the empirical base of the NASS model. This chapter will attempt to convey the general nature of the parameters estimated for these relations by presenting and discussing several tables of elasticities and flexibilities. Comments related to the elasticities and flexibilities will be general with the intent of developing an overview of the relative magnitudes of interactions and responses embodied in the model. A more detailed discussion of the nature of parameters in individual equations is presented in Appendix C.

Livestock Supply Response

Table IV.1 presents a summary of short run and long-run elasticities derived from the livestock supply response functions estimated (see Appendix C-1 for equations and parameter values). These elasticities can "superficially" be treated as comparable to short-run and long-run elasticity estimates derived in other studies. Care must be taken in making such comparisons, however, since short-run and long-run are defined in the context of the dynamic structure of the regression model. A number of ovservations about the impact of the dynamic structure assumed for the regression model (function)

Table IV.1 Livestock Supply Elasticities

Dependent Livestock Category	Independent Variables: Own Price Short	Own Price Long	Corn Price Short	Corn Price Long	Soymeal Price Short	Soymeal Price Long	Silage Available Short	Silage Available Long	Interest Rate Short	Interest Rate Long	Wage Rate Short	Wage Rate Long	Sows Farrowed Spring	Sows Farrowed Fall	# Beef Cows	# Dairy Cows	Other[9] Short	Other[9] Long	Other[9] Short	Other[9] Long
Pork Slaughter	.17	.44	-.15	-.56	-.04	--	--	--	--	--	--	--	.53	--	--	--	--	--	--	--
Fed Beef Slaughter	.45	1.31	-.40	-.49	-.21	-.38	-.47	--	-.11	-.18	--	--	--	--	3.36	3.36	--	--	--	--
Non Fed Beef Slaughter	.37	.86	--	--	--	--	-1.07	--	--	--	--	--	--	--	5.13	4.12	-.16	-.54[1]	-.04	-.97[2]
Milk Production	.06	.58	-.06	-.48	--	--	--	--	--	--	-.47	-.88	--	--	--	--	-.02	-.14[3]	--	--
Chicken Meat Production	.39	.80	.36	.73	.31	.63	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Egg Production	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.49	1.48[7]	--	--
Turkey Slaughter	.57	.85	-.45	-.676	-.01	-.014	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sows Farrowed Spring	.41	2.10[8]	.19	-.33	.15	-1.29	--	--	--	--	-1.04	--	--	.33	--	--	-.21	-.94[4]	--	--
Sows Farrowed Fall	.24	.92[8]	.02	-.62	-.02	-.71	--	--	--	--	--	--	.95	--	--	--	-.21	-.42[4]	--	--
Beef Cows	-.41	-1.36[3]	--	--	--	--	.19	1.05	-.02	-.07	--	--	--	--	--	--	.66	2.63[4]	--	.37[5]
Dairy Cows	.16	.65	-.06	-.43	--	--	--	--	--	--	-1.00	-2.45	--	--	--	--	-.07	-.32[3]	--	--
Dairy Heifers	-.06	.28	-.03	-.38	-.108	-.109	--	--	--	--	-.58	-2.26	--	--	--	--	--	-.09[6]	--	--

[a] See numbered list below for definition of these elasticities.

1 Fed Beef Price
2 Milk Price
3 Non-Fed Beef Price
4 Fed Beef Price
5 Beef Cows t-3
6 Fed Beef Price t-2
7 Gross Margin i.e. Egg Price - Feed Cost
8 Burron and Gilt Price

upon the elasticities derived warrant discussion.

Short-run response is defined in this modeling effort as the elasticity of response evolving in one year. Long-run response is defined either as the total elasticity of response evolving over the length of the polynomial lag period selected, or as the long-run elasticity implied by the partial adjustment coefficient derived for a given geometric lag model (geometric lag models were used for chicken meat, eggs, and turkey).[1]

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[1]Long-run elasticities implied by a geometric lag model are derived and calculated as follows:

$$Y_t = a(1 - \lambda) + bX_t + \quad Y_{t-1}$$

Period	$\Delta Y/\Delta X$
t	b
$t + 1$	$b + \quad b = b(1 + \lambda)$
$t + 2$	$b + \quad b(1 + \lambda) = b(1 + \lambda + \lambda^2)$
⋮	⋮
$t + j$	$b(1 + \lambda + \ldots + \lambda^i)$

hence in the long-run as $j \to \infty$

$$\frac{\Delta Y}{\Delta X} = \frac{b}{1 - \lambda} \quad .$$

In the case of polynomial lag models elasticities for various periods are calculated as follows:

$$Y_t = a + \sum_{i=0}^{n} b_i X_{t-i}$$

Period	$\Delta Y/\Delta X$
t	b_0
$t + 1$	$\sum_{i=0}^{1} b_i$
$t + n$	$\sum_{i=0}^{1} b_i$

where n is the number of periods in the polynomial lag.

The use of a polynomial lag model as opposed to a geometric lag model for a given case was found to yield different estimates for short-run and long-run elasticities. In general it was observed that the geometric lag model yielded a higher short-run elasticity but a somewhat lower long-run elasticity. (The discrepancy between long-run elasticities was not as noticeable as that between short-run elasticities.)

A more serious cause of discrepancy between elasticities depends upon whether one enters a proxy of fixed asset levels into the slaughter function for livestock. For example, the inclusion of a breeding stock variable in a slaughter function was observed to lower price elasticities significantly, particularly long-run elasticities. This alteration of price elasticities is felt to have a sound basis since the breeding stock variable is a proxy for all major long-run shifts and adjustments in production. What remains to be explained are short-run adjustments such as changing the weight at which animals are sold, the timing of slaughter, and the number of female animals withheld for breeding purpose. Weight adjustment and slaughter timing are affected only by very short-run price moves while breeding herd replacement rates are affected by longer-run factors.

The presence of a breeding stock variable in the slaughter function caused the lag structure, best suited to describe the effect of output and input priced on slaughter, to be relatively short and more heavily weighted during the early periods of the distribution. Longer and more symmetric lag structures work best when breeding stock variables are not included.

When a breeding stock variable is not placed in the regression model the lag structures reflect both longer-run breeding herd adjustments (which are the major adjustment factors) and shorter-run weight and market timing decisions. Division of the slaughter equations into weight and number units would perhaps allow better seperation of long-run and short-run phenomena. In functions to estimate total weight slaughtered with no breeding stock variable included, the lag structures derived will likely be more reflective of breeding stock adjustments than shorter-run adjustments.

Single function price elasticities reported here are not in all cases the same as the integrated model elasticity for a given period and given price change. One reason for this, in some cases is the sequential nature of equation solutions. For example, breeding herd levels may first be estimated and be specified as a function of corn price. The estimated breeding herd variable may then be entered into a slaughter function which also contains a corn price variable; hence corn price affects slaughter directly in the slaughter function and indirectly through the breeding herd variable. Both effects are combined to obtain a total or integrated effect of corn price on slaughter.

When slaughter is estimated directly from polynomial lag models and does not include a breeding stock variable in the function, it is occasionally observed that the first period of the output or input lag structure will exhibit theoretically inconsistent signs. As alluded to in the methodology chapter, this lag structure for slaughter can occur because of the short-run effect of breeding stock level adjustments upon slaughter; i.e. positive forces lead to expansion in the breeding stock levels which draws animals away from the slaughter market and vice versa.

The preceding discussion coupled with the discussion in the methodology chapter concerning the forces creating distributed lags (technical, institutional and subjective) serve to point out the author's belief that much research remains to be done on the issue of empirically describing lagged supply responses in agriculture. It is felt that commonly used empirical lag models, including polynomial lag models, do little to isolate specific causal factors, but instead serve as broad aggregate indicators of a host of factors and situations leading to lagged responses. The integration of physical system's modeling techniques and econometric lag estimation techniques is felt to be a step toward unscrambling the specific nature of agricultural supply response functions.

In observing the livestock response elasticities in Table IV.1 it can be seen that breeding herd size variables when included in the slaughter functions generally possess the greatest elasticity value of any variable. The next largest elasticity value is generally the own price elasticity. However, in numerous cases, the corn price elasticity is of a magnitude very similar to own price elasticity. In most cases soymeal price elasticity is generally smaller than own price or corn price elasticities. In a number of cases no significant response could be found to soymeal price and the variable was dropped from the equation.

Scattered throughout the livestock supply response functions are several other elasticities that deserve mention. Elasticities of response are found for the silage available (quantity of silage produced within the crop year in question) in the functions to estimate fed beef, non-fed beef and beef cows. Elasticities of response to wage rate (a proxy of labor cost and/or the opportunity cost of farm operator's labor) are found to be significant and relatively large for all categories of supply response in the dairy industry.

Livestock Product Demand Flexibilities

All livestock product demand functions are specified as price dependent: hence flexibilities as opposed to elasticities are derived. Table VI.2 presents the flexibilities derived from the parameters. The initial sepcifications of each price dependent function includes variables for all livestock quantities (in per capita terms) and income. From these specifications, statistical test values for each variable are observed and insignificant variables dropped from the equation. In several cases aggregations of a number of substitute commodity categories are used (which accounts for the identical flexibilities for several commodities in some of the categories of Table IV.2). Aggregation generally provides stronger t-values for the parameters, slightly better tracking in terms of turning point accuracy but not necessarily better $\bar{R}^2$ values. Per capita income is indicated to be a highly significant variable (possessing a significance level greater than .1) in every equation except the milk price function. The flexibilities of the income variables indicate that

Table IV.2 Livestock Product Demand Flexibilities (Farm Level)[1]

Dependent Livestock Price	Independent Quantity Variable							
	Pork	Fed Beef	Non-Fed Beef	Milk	Chicken	Turkey	Eggs	Income
Pork	-2.089	-1.647			-.380	-.380		1.747
Fed Beef	- .037	-1.701	-.651			-.038		1.954
Non Fed Beef		-2.263	-1.054					2.849
Milk	-2.525	-2.525	-2.525	-.628	-.093	-.093	1.496	.417
Chicken		-1.323			-1.583	-.574		2.228
Turkey		-1.081			-.778	-.653		1.450
Eggs	- .011	- .011	- .011		-.011	-.011	-3.086	3.431

[1]All prices are farm level prices received by farmers. Quantities are expressed in pounds of live-weight for pork, fed beef, and non-fed beef, pounds of fluid milk, dozens of eggs and pounds of ready-to-cook chicken and turkey.

all commodities listed are superior goods, i.e. a positive price response to income growth is indicated. In general, the flexibilities are of reasonable magnitude for all equations. The income flexililities for chicken and particularly egg prices are, however, unexpectedly high in relation to other flexibility estimates in the table.

One case of complimentarity is indicated in the set of demand relations between milk and eggs. Complimentarity of milk and eggs appears plausible at the farm level of demand due to the complimentary use of these commodities in making processed foods. The reverse case of complimentarity in the egg price function does not occur. The milk quantity variable generated an insignificant positive sign when tested in the egg price function and thus was dropped.

Feed Demand Response

Elasticities derived for each of eight categories of livestock demand for feedgrain and high protein feed are presented in Tables IV.3 and IV.4 respectively. The elasticities presented include the short and long-run (where applicable) elasticities of demand with respect to corn price, soymeal price, silage available, product price and output level.

Feed demand functions in most cases have been specified as partial adjustment or habit persistence models. This specification is based upon the rationale that producers generally develop a ration which appears to work well for their situation and then change only when conditions are significantly altered.

Table IV.3 Own and Cross Elasticities of Derived Feedgrain Demand

Feedgrain Consumption Category	Corn Price		Soymeal Price		Silage Avail.		Output Price		Output Level		Adjust-ment Rate
	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run	
Pork	-.249	- .433	.078	.136	--	--	--	--	.442	.769	.575
Fed Beef	-.280	-3.060	.419	4.580	-.209	-2.290	.362	6.830	.008	.840	.091
Non Fed Beef	-.691	-1.433	.515	1.068	-.444	.921	.164	.340	--	--	.482
Milk	-.180	- .783	.029	.124	--	--	.661	2.869	1.680	7.338	.230
Dairy Heifers	-.189	- .396	.370	.775	--	--	--	--	.661	1.383	.478
Chicken Meat	-.070	- .070	-.046	-.046	--	--	.481	.481	.812	.812	1.000
Eggs	-.018	- .022	.239	.295	--	--	.276	.341	2.008	2.483	.809
Turkey	-.779	-13.061	-.106	-1.643	--	--	.941	14.577	--	--	.065
Weighted Average Elasticity	-.236	-1.220	.165	.974							

Table IV.4 Own and Cross Elasticities of Derived High Proetin Feed Demand

High Protein Feed Consumption Category	Corn Price		Soymeal Price		Silage Avail.		Output Price		Output Level		Adjustment Rate
	Short Run	Long-Run	Short Fun	Long-Run	Short Run	Long-Run	Short Run	Long-Run	Short-Run	Long-Run	
Pork	.610	.610	-.070	- .070	--	--	.060	.060	.400	.400	1.000
Fed Beef	.138	.650	-.289	-1.350	--	--	.219	1.030	1.110	5.200	.214
Non-Fed Beef	.135	.160	-.874	-1.060	--	--	.337	.410	--	--	.822
Milk	--	--	--	--	--	--	--	--	.743	1.938	.383
Dairy Heifers	-.791	-2.117	-.505	-1.350	--	--	--	--	1.058	2.828	.374
Chicken Meat	-.106	- .106	-.023	- .023	--	--	.568	.568	.931	.931	1.000
Eggs	-.386	- .386	-.419	- .419	--	--	.335	.335	--	--	1.000
Turkey	--	--	-.468	- .737	--	--	--	--	.128	.203	.635
Weighted Average Elasticity	.046	.062	-.261	- .406							

In the case of feeding activities where special equipment is required for certain rations (i.e. silage with grain) asset fixity created by equipment investment may prevent rapid ration adjustment. Lastly in the case of livestock producers who grow their own feed, a lack of flexibility in rations may be expected. (See Appendix C-3 for further discussion of the rationale for using a partial adjustment model specification for feed demand).

The adjustment rates for feed demands are presented in Tables IV.3 and IV.4.[1] In general the adjustment rates estimated for the use of high protein feeds are greater than those for the use of feed grains. This may be due to the fact that high protein feeds are generally purchased while grain is often partially or entirely self-produced.

The adjustment rates estimated were generally greater for poultry followed by pork dairy and beef. This ordering appears to substantiate previous arguments for specifying a partial adjustment model; i.e. beef and dairy enterprises are characterized by self-produced feeds, storage and feeding systems requiring special equipment etc. For both input prices and output levels, a wide range of feed demand elasticities are obtained. In general, (with some notable exceptions) the feed demand elasticities associated with output level changes are the largest. This implies that the greatest sensitivity of feed demand to output levels.[2] One might

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[1]The adjustment rate is calculated as 1-b where b is the coefficient on the lagged dependent variable. Where no lagged dependent variable is included the adjustment rate is assumed to be one.

[2]Recall that output level enters theoretically as a proxy for fixed asset levels.

expect that changes in output and changes in feed demand would be nearly proportional. (This indeed would be the assumption of a model which used fixed feeding rates per animal unit.) This expectation is substantiated by the fact that more than two-thirds of the short-run feed demand elasticities estimated for output level can not be said to be significantly different from one.

Product prices generally contain positive elasticity values of a significant magnitude. The positive sign of the elasticity indicates that more feed is used ceteris paribus as product prices rise.

Several cases of complimentarity between feedgrains and high protein feeds are indicated by the estimated signs for the price elasticities of corn and soymeal. Specifically in the case of feedgrain demand, high protein feeds are indicated to be compliments in chicken and turkey production. In the case of high protein feed demand, feedgrains are indicated to be complimentary feed for dairy heifers, and in chicken and egg production. In the case of chicken, the complimentarity holds both ways.

The relative elasticities indicate that in general when soymeal prices change, corn consumption is definitely affected; however the opposite is not true; when corn prices change, soymeal consumption is affected very little ceteris paribus. Hence, "irreversibility of substitution" is indicated.

To see this more clearly, a weighted average set of long-run and short-run corn and soymeal price elasticities was calculated.[1]

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[1]The weights used were the proportion of feedgrains and high protein consumed by each category of animals. These weights are informative

(footnote continued)

The weighted average corn price elasticity indicates that corn price changes have very little net effect upon high protein feed consumption. However the weighted average soymeal price elasticity shows that for the sector, some substitution of high protein feed for corn can be expected.

A plausible explanation of the irreversibility indicated here may be related to the fact that protein meal is generally a purchased input and feedgrains are not. This suggests that when high protein feed prices rise, farmers will quickly cut back on protein feeds and attempt to substitute feedgrains, and likewise will resume feeding

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1 continued

in themselves and show the dominance of pork in livestock feed demand. They also show the relative heavy use of protein feeds in the poultry categories. Beef and dairy, because of their intensive use of roughages are relatively smaller users of feedgrain and protein feeds than might at first be expected.

Category	Percent of Feedgrains Consumed	Percent of High Protein Feed Consumed
Pork	39.2	21.6
Fed Beef	16.4	7.9
Non-fed Beef	5.0	9.2
Milk	15.6	16.8
Dairy heifers	2.0	2.0
Chicken	5.2	17.1
Eggs	14.0	19.5
Turkey	2.6	5.9
	100.0	100.0

Over the time period 1950-71 these categories of livestock accounted for an average of approximately three-fourths of all feed consumption. This percentage has steadily increased through the period.

high protein feeds when the price of protein feeds fall. On the other hand, when corn prices rise, high protein feeds are not substituted for feedgrains and vice versa when corn prices fall.

It is believed that the model is crudely describing a perceived practice of farmers to feed some adequate level of protein feeds when protein feed price is low or reasonable, and then "skimp" on protein feeds when the protein feed price is high. A similar reaction for corn does not occur because the price of corn perceived by the producer is more often an opportunity cost of selling versus feeding the corn; hence the price is not as clearly perceived as the market price the producer is paying to purchase processed protein feeds.

This same phenomena of differential response to internal cost or opportunity pricing of feedgrains (due to partial self-production of feedgrain inputs) versus clear-cut acquisition pricing of protein feeds appears evident in the livestock supply response functions. Output response to high protein feed price appears to be large and relatively as strong as response to feedgrain price in a one-year period, but the response to protein feed prices after one year is much weaker than that to feedgrain prices. Stated alternatively, output response to protein feed price is sharp and abrupt, while output response to feedgrain price is not so abrupt but is cumulatively greater over the total length of the response. (See Appendix C-1 for further discussion and lag structure parameters.) This phenomena is more clearly seen in a quarterly pork supply model specified by the author[1] than in the annual livestock supply model used in this study.

Crop Production Response

The crop subcomponent of the NASS model contains acreage planted, acreage harvested and yield functions. The major economic interactions of the crop subcomponent are contained in the acres-planted functions. Table IV.5 presents the elasticities of response to price and policy variables contained in the seven crop acreage planted relations in the model.

Two policy variables are used to describe the effect of government crop policies existing during the 50s, 60s and early 70s. These variables are PVI, an "effective support price" variable, and PV2, an "effective diversion payment" variable. The variables were first defined by Houck and Ryan[2] and were used by McKeon[3] in his dissertation work at Michigan State University. (The acreage planted functions in this model are derived from McKeon's dissertation and his subsequent work.) The variables are defined as follows.

$$PV1 = rPA$$

$$PV2 = wPR$$

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[1]James N. Trapp, "A Polynomial Distributed Lag Model of Pork Production Response." Michigan State University Department of Agricultural Economics Staff Paper #75.27, August 1975.

[2]J. P. Houck and M. E. Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," American Journal of Agricultural Economics, Vol. 54, May 1972.

[3]John McKeon, "Farm Commodity Programs: Their Effect on Planting of Feed Grains and Soybeans." Unpublished Ph.D. dissertation, Michigan State University, 1974.

Table IV.5 Crop Acreage Planted Elasticities for Price and Policy Variables

Thousands of Acres Planted	Independent Variables																	
	PVIC	PVIO	PV1B	PV1SH	PV1W	PV1CT	PV2C	PV2B	PV2SH	PV2W	PV2CT	PC-1	PO-1	PB-1	PSH-1	PSB-1	PW-1	PCT-1	APW
Corn	.132						-.108					.037				-.050	-.157		
Oats		.010											.161						.521
Barley			.107					-.064					-.687	.460					1.161
Sorghum									-.166						.678		-.179	-.221	
Soybeans	-.333 (1.123)[1]	-.452 (1.524)[1]														.260 (.877)[1]	-.087 (.293)[1]		
Wheat					.693					-.015		-.052			-.237		.472		
Cotton						.836					.045					1.057		1.078	

[1]Long-Run Elasticities

Variable Descriptions

Policy Variables

PV1 - Effective Support Price
PV2 - Effective Diversion Payment

Crop Subscripts

C - Corn
O - Oats
B - Barley
SH - Sorghum
SB - Soybeans
W - Wheat
CT - Cotton

Other Subscripts

P - Price
-1 - Lagged one period
APW - Acres planted of wheat

where

PV1 - effective price support

PV2 - effective diversion payment

PA - announced price support

r - an adjustment factor based upon planting restrictions

PR - Payment rate for diversion

w - Proportion of acreage eligible for diversion

A complete description of how the formulas are operated to obtain the variables used can be found in the appendix of McKeon's dissertation.

In observing the elasticities for various crops it is noted that the policy variables quite often have relatively larger elasticities than the lagged price variables. This is particularly true for the major cash crops of corn, wheat and soybeans. Note that soybean acreage planted is not affected by its own policy variables[1] but is strongly influenced by corn policy variables.

With regard to minor crops of oats, barley and sorghum, prices appear to play a relatively more dominate role in acreage planting decisions. In the case of cotton, relatively high elasticities of response are observed for both policy and price variables.

A further discussion of the effect of policy on crop plantings during the 50s, 60s and early 70s and an interpretation of the empirical parameters generated for the variables used to describe the influence of these policies is contained in McKeon's dissertation.

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[1]Historically soybean support price has typically been well below soybean market price. Acreage restrictions or diversion payments have not been present for soybeans.

CHAPTER V

MODEL PERFORMANCE AND TESTING

Descriptions of tests of the integrated model's performance will be given in this chapter to support the validation of the model. Tests conducted for the integrated model consist of several types. First, accuracy analysis is made of the model's historical tracking ability, both within the period for which parameters were estimated and beyond the estimation period. Second, the dynamic properties of the model are tested with respect to stability, cyclical properties and sensitivity. Last, various cross model consistency criteria are considered. In addition to reporting on the above tests of model performance, a general discussion of model validation principles is presented in this chapter.

Model Validation Principles

Validation seeks to establish whether or not the system model is a representation of the "real world" which can be used to satisfy the purpose of the modeling effort. As such, validation is often an iterative process that leads to successive tests and refinements in the model. Ultimately, if the process of validation is successful, a model which is acceptable to and used by the modeler and/or his clientele will emerge.

A number of authors have written about the process of developing objective verification procedures for econometric models. Theil[1], in his discussion of forecasting performance, states that for a model to be scientifically "verifiable" it must be possible to determine after a certain time whether the predictions are correct or incorrect, and both possibilities must exist. In addition it is necessary that the line of reasoning which underlies the prediction can be verified. This implies that a line of thought exists in making the forecast and it can be followed by others.[2] Theil concludes that forecasting procedures, to be verifiable, must be "based upon theoretical considerations - however simple - and on empirical observations obtained beforehand - however scanty and crude."[3]

Theil presents a useful conceptual breakdown of the process of analyzing forecast and validating the forecast model. He divides the analysis into three main categories. The first category is called verification or the determination of whether a prediction comes true. Closely related to verification is "accuracy analysis." Accuracy analysis is concerned with forecasting errors; i.e. with the differences between predictions and outcomes. Accuracy analysis does not concern itself with the process by which the predictions are generated.

The second main activity in analyzing forecasts and validation of the forecasting model is a review of the process of the generation

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[1]Henri Theil, Economic Forecast and Policy, Amsterdam, North Holland Publishing Company, 1965.

[2]The construction of quantifiable, documented models would appear to greatly facilitate this condition of "verifiableness" put forth by Theil.

[3]Theil, Economic Forecast and Policy, p. 14.

of predictions. In this review the theory and empirical measures used are scrutinized for consistency and logic.

Theil defines the third category of the validation process, purpose of the prediction. One must consider in verifying the model whether it provides the information necessary to fulfill the purpose of the model and whether it does so in a logical manner.

The relation of purposes to the development of accuracy measures is an important consideration. In general, accuracy measures are based on some type of "loss function" or measure of discrepancy between forecasted and observed values, i.e. squared error. In defining a loss function the weight ascribed to an error of a given magnitude should be related to the purpose of the model. This requires knowledge of decision-makers, utility functions, and the process by which decision errors will be made when forecast errors occur. Teigen[1] presents an example of an accuracy measure designed with decision-maker's actions and utilities considered. Teigen considers the loss in profits encountered by a beef producer who adjusts production in a systematic manner based upon the forecast information of an econometric model. The producer's loss function is defined in terms of profit-loss due to forecast error. In general, when one is conducting accuracy analysis of a model with broad purposes and many prospective clientele groups, less specific and simpler concepts of accuracy analysis more remotely connected to model purpose must be used.

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[1]Lloyd D. Teigen, "Costs, Loss and Forecasting Error: An Evaluation of Models for Beef Prices," Unpublished Ph.D. dissertation, Michigan State University, 1973.

Shapiro[1] and Fromm[2] conduct discussions of model validation which add several additional points of interest to Theil's discussion. Shapiro states that "construction and evaluation of large econometric models can be thought of as composed of two interrelated stages - formulation and estimation of model components and evaluation of the model as a whole." The first stage involves a number of activities. One of the activities consists of formulation or specification of the model's abstract structure. In specifying the model, the theory or logic leading to the specification should be outlined. Fromm points out that while model-builders should attempt to validate their model and its specification based upon theory, in reality they cannot do so. Rarly is economic theory so well developed as to be capable of linking specific equations with a complete theory of behavior. Hence the modeler and/or user is left to draw his own inferences.

Most rigorous theoretical derivations of equation specifications require stringent assumptions about objective functions, the nature of uncertainty, etc. These assumptions are especially difficult to fulfill, given the level of aggregation required to reduce the model to a workable size and/or to obtain compatibly defined sets of data. Fromm concludes that, "Faced with these limitations, perhaps the model - builders have little recourse until theory and data are improved, than the reduced-form approximations that are so prevalent in econometric work."

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[1]Harold T. Shapiro, "The Validation and Verification of Complex Systems Models." American Journal of Agricultural Economics, 55 (May, 1973), pp. 250-58.

[2]Gary Fromm, "Implications To and From Economic Theory in Models of Complex Systems." American Journal of Agricultural Economics, 55 (May, 1973), pp. 258-71.

Testing the integrated model can proceed in several ways. An examination of the theory and logic of the integrated structure is useful just as is an investigation of the theory supporting each function. To examine the overall structural logic of the model the purpose of the model must be kept in mind.

Examination of the integrated model's ability to reproduce historical relations can be conducted in several ways. Historical simulation can be either deterministic or stochastic (with regard to exogenous variables) and either static (one period) or dynamic (multiperiod) in nature. A minimal requirement would be the comparison of historical observation with simulated data generated by a deterministic single-period simulation. A fuller requirement would be to compare observed values with simulated values generated from a stochastic multi-period simulation reaching into periods beyond the historical estimation period.

Various numerical values describing the integrated model's ability to track (generalized accuracy measures) have been suggested in the literature. Shapiro[1] presents the following summary listing of nonparametric measures describing the relation between simulated and observed data:

A. Single-variable measures

1) Mean forecast error (changes and levels).

2) Mean absolute forecast error (changes and levels).

3) Mean squared error (changes and levels).

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[1] Shapiro, "The Validation and Verification of Complex System's models", p. 257.

4) Any of the above relative to:

a) the level of variability of the variable being predicted.

b) A measure of "acceptable" forecast error for alternative forecasting needs and horizons.

B. Tracking measures

1) Number of turning points missed.

2) Number of turning points falsely predicted.

3) Number of under - or over predictions.

4) Rank correlation of predicted and actual changes (within a subset of "important" actual movements).

5) Various tests of randomness.

a) of directional predictions.

b) of predicted turning points.

C. Error decomposition

1) Comparison with various "naive" forecast.

2) Comparison with "judgmental," "consensus," or other non-econometric forecasts.

3) Comparison with other econometric forecast.

In using any of these measures for an integrated model a problem arises because they are specific to individual variables. Developing a tracking measure for an integrated model would suggest averaging a given measure over all endogenous variables of the model. In averaging the measure for each variable, some weighting of the variables in relation to the purpose of the model may be helpful to develop a criteria in determining which version of the model best suits a given purpose, (i.e., Teigen's approach to determining the effect of various forecast errors on beef producer profit).

In most cases, tests in addition to accuracy measures or "tracking" properties, are desired for integrated simulation models. Economists generally desire to investigate whether a dynamic econometric model responds to various types of stimuli in a fashion anticipated or suggested by economic theory. Theory suggests certain acceptable integrated relations with regard to dynamic and steady state multipliers, cyclical patterns and model stability.

Observation of the model's response to changes in various exogenous variables (or parameters) is often referred to as "sensitivity analysis." Sensitivity analysis is useful in isolating and focusing upon areas in the model where priority in improving accuracy of parameters and tracking should be given. Areas of the model which are quite sensitive to change should be given priority in iterative refinement processes since relatively large improvements in integrated performance may follow from small improvements on the accuracy of such areas.

A final method in which the model's integrated operation can be verified is by testing to see if various cross relationships not explicitly modeled are realistic. Examples for the NASS model of this type might include calculations of implied per capita meat and grain production, gross farm income implied by the model, gross margins on livestock products, etc. In order for such cross relations to consistently hold, broad segments of the model must be continuously accurate and properly interfaced.

Tracking Tests of the NASS Model

Two types of tracking tests -- comparisons of simulated and observed historical data -- were performed for the NASS model. The first (and less demanding) tracking test was made by making a series of one-year estimates with all exogenous variables deterministically entered; i.e. entered at their observed historical value. The second tracking test was conducted with a set of multi-period estimates. In this comparison all exogenous values which are lagged values of endogenous variables are entered as the values estimated by the model.

Plots of each of these types of tracking comparisons will be presented for the major endogenous variables of the model. In addition, several tables of accuracy measures describing the relation between estimated and actual values will be presented. A number of accuracy measures are presented to compare the implications of several measures and also to attempt to provide the measure which may be most meaningful to any of a wide number of interested persons with different backgrounds and purposes. The accuracy measures used and the formulas for them are presented in Table V.1.

The first eight accuracy measures relate the predicted to actual value in fairly stright forward relations which are relatively self-explanatory by their formula and title; i.e. mean squared error, average absolute value, maximum absolute error, average relative (percentage) error, average forecast bias, forecast slope (determined by regressing predicted upon actual values), forecast intercept (of the regression of predicted upon actual values) and forecast correlation.

Table V.1 Measures of Forecasting Accuracy[1]

Measure	Range	Comments
1. Mean Squared Error $M.S.E. = 1/N \sum_{i=1}^{N} (r_i - p_i)^2$	Non-negative	
2. Average Absolute Error $A.A.E. = 1/N \sum_{i=1}^{N} \lvert r_i - p_i \rvert$	Non-negative	Zero is optimal
3. Maximum Absolute Error $\text{Max AE} = \text{Max} \lvert r_i - p_i \rvert$	Non-negative	
4. Average Relative Error (In percentage terms) $A.R.E. = 100/N \sum \left\lvert \frac{r_i - p_i}{r_i} \right\rvert$		
5. Forecast Bias $\text{Bias} = 1/N \sum_{i=1}^{N} (r_i - p_i)$	Real	Zero is optimal
6. Forecast Slope $b_1 = \frac{\sum_{i=1}^{N} (r_i - r)(p_i - \bar{p})}{\sum_{i=1}^{N} (p_i - \bar{p})^2}$,	Real	Plus one is optimal
7. Forecast Inercept $a = \bar{p} - b_1 \bar{r}$	Real	Zero is optimal
8. Forecast Correlation $R = \frac{\sum_{i=1}^{N} (r_i - \bar{r})(p_i - \bar{p})}{\sqrt{\sum_{i=1}^{N} (r_i - \bar{r})^2 \sum_{i=1}^{N} (p_i - \bar{p})^2}}$	[-1.0, 1.0]	Plus one is optimal
9. Turning Point Errors (T.P.E.)[2] Number of incorrect reversals of direction predicted or failed to be predicted.	[0, N-1]	Zero is optimal

Table V.1 (continued)

Measures	Range	Comments
10. Inequality Measures[2]		
$U_1A = \dfrac{\sqrt{\sum_{i=1}^{N} (r_i - p_i)^2}}{\sqrt{\sum_{i=2}^{N} (r_i - r_{i-1})^2} + \sqrt{\sum_{i=2}^{N} (p_i - r_{i-1})^2}}$	[0,1]	If $U_1 > 2/2$, r and p may be negatively correlated.
$U_2A = \dfrac{\sqrt{\sum_{i=1}^{N} (r_i - p_i)^2}}{\sqrt{\sum_{i=2}^{N} (r_i - r_{i-1})^2}}$	Non-negative	If $U_2 < 1.0$, the forecast is better than a no-change extrapolation.
$U_1 = \dfrac{\sqrt{\sum_{i=1}^{N} (Ar_i - Ap_i)^2}}{\sqrt{\sum_{i=2}^{N} \Delta r_i^2} + \sqrt{\sum_{i=2}^{N} \Delta p_i^2}}$	[0,1]	
$U_2 = \dfrac{\sqrt{\sum_{i=2}^{N} (\Delta r_i - \Delta p_i)^2}}{\sqrt{\sum_{i=1}^{N} \Delta r_i^2}}$	Non-negative	If $U_2 < 1.0$, the forecast is better than an extrapolation of the previous one-year trend.
11. Inequality Measure Decompositions for U_1 and U_2[2]		
a) Bias Proportion		
$U^M = \dfrac{(\Delta\bar{p}_i - \Delta\bar{r}_i)^2}{U_2NUM}$	[0,1]	$U^M + U^S + U^C = 1$

Table V.1 (continued)

Measure	Range	Comments
11. Continued		
b) Variance Proportion		
$U^S = \frac{(S_p - S_r)^2}{U_2NUM}$	[0,1]	
c) Covariance Proportion		
$U^C = \frac{2(1 - R)\ Sp\ Sr}{U_2NUM}$	[0,1]	
d) Regression Proportion		
$U^R = (Sp - Rsr)^2$	[0,1]	$U^M + U^R + U^D = 1$
e) Disturbance Proportion		
$U^D = \frac{(1 - R^2)Sr^2}{U_2NUM}$		

where

$$Sp^2 = \frac{1}{N-1} \sum_{i=2}^{N} (\Delta p_i - \bar{p}_i)^2$$

$$Sr^2 = \frac{1}{N-1} \sum_{i=2}^{N} (\Delta r_i - \bar{r}_i)^2$$

$$U_2NUM = \frac{1}{N=1} \sum_{i=2}^{N} (\Delta p_i - \Delta r_i)^2$$

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[1] r_i represents an observed (historical) value

p_i represents a predicted value

[2] A further discussion of this accuracy measure with regard to its definition, calculation and interpretation is presented in Appendix D.

Accuracy measures nine through eleven (turning point errors, inequality measures, and inequality decompositions) are less straight forward in nature and interpretation. These measures are based upon Henri Theil's work[1]. A detailed discussion of the rationale, interpretation and use of these measures is presented in Appendix D. Briefly, U1 and U2 are the inequality measures developed by Theil for use with first difference single period forecast models. The measures place special emphasis upon the model's ability to predict turning points as well as its accuracy in other ways. U2 has the property of allowing one to determine if the forecast is better than the niave model of extrapolating the previous year's trend or growth rate. A value of less than one for U2 indicates the model's performance is better than a naive trend model.

U_1A and U_2A are the actual variate equivalents of U_1 and U_2. Their interpretation is different than that for the first difference-based inequality coefficients (see Appendix D). U_2A provides another naive model comparison test. If U_2A is less than one, the model performs better than a naive acutal variate no-change model.

Tables V.2 and V.3 present the accuracy measures for 33 key domestic endogenous variables of the model for a set of ten single period forecast and for a ten-year multi-period forecast or simulation.

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[1]Henri Theil, <u>Principals of Econometrics</u>, (New York: John Wiley and Sons, 1971).

Henri Theil, <u>Applied Economic Forecasting</u>, IV (Chicago: Rand McNally and Company, 1966).

Average accuracy measures are presented where appropriate. (in total the model contains 88 endogenous domestic variables).

Figures V.1 - V.12 present plots of the actual values and the single period and multiple period estimates for several of the endogenous variables listed in Tables V.2 and V.3. These figures when related to Tables V.2 and V.3 enable a representative physical or visual comprehension to be formed of the tracking implied by accuracy measures within the tables. Each of these tables can not be discussed in detail, but several points and comparisons are noteworthy. In regard to single period estimates, it is observed that the model easily performs better than the naive actual variate no-change model; i.e. the average U_2A value is .763. The model on the average, however, performs only a little better than the naive previous year trend model, -- U_2 equals .994. It should be noted that for the 33 variables listed in the table the model does perform significantly better than the naive first difference model. (U_2 equals .883 for these variables)[1].

The typical percentage error of the single period estimates is generally in the four percent range. However, extremely high percentage

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[1]The major variables excluded from the table which are typically forecast worse than average, include feedgrain and high protein feed consumption estimates by category of livestock. Aggregate or total feegrain and protein consumption forecast obtain relatively good R values (.853 and .939) and low percentage error (4.462 and 4.364) but are not better forecast than could be obtained with a naive first difference forecast model. In general the same remarks hold true for individual categories of feedgrain and high protein feed consumption.

Other endogenous variables omitted from the table include oats, barley and sorghum quantities and prices, acres of all crops harvested for grain and/or silage, low grade beef imports, human consumption of grains, seed demand, export prices and several other miscellaneous variables.

Table V.2 1962-71 Single Period Estimation Accuracy Measures

	Average Value	Maximum Absolute Error	Average Absolute Error	Average Bias	Average Percentage Error	Mean Square Error	R	U1	U2A	U2	Slope	Turning Point Errors
Crop Price												
Corn ($/bu.)	1.137	.134	.085	.016	7.467	.009	.850	.434	.748	1.168	.432	4/9
Wheat ($/bu.)	1.482	.128	.066	.008	4.645	.006	.980	.231	.305	.446	.997	0/9
Soybeans ($/bu.)	2.557	.206	.085	.028	3.309	.011	.894	.387	.530	.899	.847	4/9
Crop Quantities												
Corn (Mil. bu.)	4317.029	405.960	109.909	1.660	2.771	24.596*	.965	.184	.233	.356	.999	2/9
Wheat (Mil. bu.)	1362.890	129.447	42.822	23.760	3.176	3.521*	.952	.248	.449	.523	.867	1/9
Soybeans (Mil. bu.)	936.296	69.255	26.901	14.538	3.136	1.117*	.988	.348	.443	.678	.955	0/9
Livestock Prices												
Fed Beef ($/cwt.)	25.338	2.877	1.031	-.394	4.183	1.933	.846	.437	.753	1.209	.596	1/9
Non-Fed Beef ($/cwt.)	16.629	3.136	1.332	-.399	8.048	2.624	.767	.614	1.194	1.965	.530	4/9
Pork ($/cwt.)	19.114	3.434	1.434	.094	7.560	2.984	.809	.362	.408	.609	1.081	3/9
Milk ($/cwt.)	4.913	.316	.096	-.028	1.939	.016	.898	.489	.777	.851	1.139	3/9
Chicken ($/cwt.)	14.336	2.255	1.118	-.143	7.760	1.650	.877	.636	1.095	1.564	.632	5/9
Eggs (Bil. doz.)	34.578	5.907	2.832	.066	8.414	10.764	.643	.670	.739	1.018	.647	5/9
Turkey ($/cwt.)	21.535	2.917	1.404	.245	6.463	2.685	.795	.776	.997	1.617	.645	7/9
Livestock Quantities												
Fed Beef (Bil. lbs.)	27.583	1.094	.402	-.044	1.487	254.238	.982	.319	.384	.654	.934	2/9
Non-Fed Beef (Bil. lbs.)	6.723	1.685	.755	.225	11.769	774.650	.345	.733	.471	1.354	.538	4/9
Pork (Bil. lbs.)	19.936	1.575	.498	-.136	2.424	394.898	.896	.371	.410	.666	1.093	2/9
Milk (Bil. lbs.)	120.503	1.765	.734	.086	.605	821.543	.971	.352	.385	.576	.961	1/9
Chicken (Bil. lbs.)	7.149	.178	.091	-.002	1.268	12.185	.993	.223	.305	.426	1.020	0/9
Eggs	5.580	.171	.059	-.003	1.052	6.398	.882	.653	.693	.986	1.184	3/9
Turkey (Bil. lbs.)	1.588	.218	.083	-.005	4.924	11.069	.835	.632	.774	.979	.785	1/9
Beef Cows (Mil.)	33.488	.634	.357	.021	1.077	170.150	.990	.243	.323	.468	1.040	1/9
Dairy Cows (Mil.)	14.315	.198	.067	.006	.505	8.316	.999	.084	.148	.170	.994	0/9
Grain Stocks												
Gov. Wheat (Mil. tons)	18.348	9.259	2.629	1.670	16.282	15.093*	.913	.351	.608	.806	.883	0/9
Private Wheat (Mil. tons)	4.382	2.103	.748	.271	115.383	1.031*	.953	.373	.669	.589	1.550	1/9
Gov. Feedgrain (Mil. tons)	5.851	3.087	1.221	.130	34.919	2.435*	.934	.485	.659	1.061	.991	3/9
Private Feedgrain (Mil. tons)	42.309	15.426	6.478	3.154	16.622	57.425*	.544	.571	1.014	1.098	.654	3/9
Soybeans (all) (Mil. tons)	2.964	2.510	.879	-.160	35.298	1.356*	.848	.535	.584	.936	.930	5/9
Feed Consumption												
Feedgrain (Mil. tons)	129.463	11.094	5.620	-.511	4.462	39.974*	.853	.633	.933	1.437	.792	4/9
Soybean Meal (Mil. tons)	11.457	1.483	.510	-.285	4.364	.438*	.939	.436	.766	1.005	.928	1/9
Wheat (Mil. tons)	3.632	2.951	1.270	-.164	64.963	2.289*	.814	.753	.765	1.057	1.411	5/9
Grain Exports												
Feed Grain (Mil. tons)	21.757	3.730	1.522	-.179	6.859	3.564*	.844	.378	.419	.608	1.040	3/9
Wheat (Mil. tons)	21.327	4.675	1.765	-.711	8.824	5.056*	.709	.392	.541	.784	.817	1/9
Soybeans (Mil. of meal equivalents)	9.815	1.449	.726	.628	8.225	.845*	.978	.338	.545	.595	1.014	1/9
Model Average					8.685		.806	.475	.763	.994		2.58/9
Average of 33 Values in this Table					11.626		.863	.444	.623	.883		2.42/9

* The decimal point has been shifted three places to the right for this value.

Table V.3 1962-71 Ten Year Estimation Accuracy Measures

	Average Value	Maximum Absolute Error	Average Absolute Error	Average Bias	Average Percentage Error	Mean Square Error	R	U1	U2A	U2	Slope	Turning Point Errors
Crop Prices												
Corn ($/lb.)	1.137	.121	.046	.000	4.064	.004	.954	.217	.485	.469	.705	3/9
Wheat ($/lb.)	1.482	.159	.060	-.019	3.981	.006	.982	.249	.303	.466	.971	3/9
Soybeans ($/lb.)	2.551	.238	.096	-.014	3.732	.017	.811	.421	.669	.843	.795	3/9
Crop Quantities												
Corn (Mil. bu.)	4317.029	347.040	109.379	8.371	2.743	19.472*	.973	.156	.208	.314	.972	1/9
Wheat (Mil. bu.)	1362.890	126.368	49.927	19.864	3.542	3.767*	.941	.297	.465	.570	.880	1/9
Soybeans (Mil. bu.)	936.296	105.867	42.195	26.158	4.818	2.514*	.974	.415	.665	.804	.965	1/9
Livestock Prices												
Fed Beef ($/cwt.)	25.338	7.038	4.097	1.146	16.151	21.894	.055	.678	2.534	2.452	.023	3/9
Non-Fed Beef ($/cwt.)	16.629	6.844	3.734	1.054	22.253	19.021	-.036	.759	3.215	3.184	-.016	6/9
Pork ($/cwt.)	19.114	7.354	3.373	.734	18.129	15.524	.218	.712	.930	1.320	.195	5/9
Milk ($/cwt.)	4.913	.269	.087	.037	1.825	.012	.950	.434	.657	.746	1.256	1/9
Chicken ($/cwt.)	14.336	4.940	2.372	.322	17.369	7.834	.427	.869	2.385	3.172	.251	6/9
Eggs ($/doz.)	34.578	6.035	3.078	-.148	9.135	11.927	.587	.750	.778	1.127	.619	6/9
Turkey ($/cwt.)	21.535	5.030	2.549	.334	12.336	8.630	.536	.869	1.787	2.561	.338	8/9
Livestock Quantities												
Fed Beef (Bil. lbs.)	27.584	2.727	1.353	-.362	4.862	2743.362	.896	.524	1.261	1.310	.659	2/9
Non-Fed Beef (Bil. lbs.)	6.723	3.393	1.304	-.406	18.559	2687.747	-.411	.813	1.809	1.550	-.348	6/9
Pork (Bil. lbs.)	19.936	2.853	.963	-.221	4.722	1550.311	.529	.799	.762	1.304	.642	5/9
Milk (Bil. lbs.)	120.503	6.095	3.056	-1.133	2.555	12897.574	.776	.457	1.624	1.172	.538	2/9
Chicken (Bil. lbs.)	7.150	.538	.236	-.002	3.190	78.270	.964	.473	.773	.954	1.171	2/9
Eggs (Bil. doz.)	5.581	.145	.066	.007	1.172	6.970	.874	.730	.724	1.003	1.229	5/9
Turkey (Bil. lbs.)	1.588	.325	.083	-.018	4.843	15.008	.768	.775	.901	1.258	.756	3/9
Beef Cows (Mil.)	33.488	2.502	1.302	-.220	3.849	2296.698	.902	.520	[illegible]	1.043	.753	2/9
Dairy Cows (Mil.)	14.315	1.458	.745	-.329	5.508	846.053	.888	.842	1.489	.907	.911	3/9
Grain Stocks												
Gov. Wheat (Mil. tons)	18.348	8.226	3.896	3.465	28.727	23.312*	.917	.215	.701	.404	1.021	0/9
Private Wheat (Mil. tons)	4.382	2.039	.891	.112	115.943	1.165*	.958	.442	.709	.653	1.746	3/9
Gov. Feedgrain (Mil. tons)	5.851	7.000	2.846	1.559	82.565	12.449*	.644	.439	1.361	1.049	.887	2/9
Private Feedgrain (Mil. tons)	42.309	13.352	5.573	4.598	14.027	44.702*	.719	.358	.813	.629	.985	3/9
Soybeans (Mil. tons)	2.964	2.345	1.015	-.076	35.375	1.544*	.836	.532	.603	.921	.845	3/9
Feed Consumption												
Feedgrains (Mil. tons)	129.463	10.289	5.085	-.596	4.050	35.844*	.844	.526	.883	1.170	.991	3/9
Soybean Meal (Mil. tons)	11.457	1.704	.630	-.157	5.285	.708*	.888	.619	.943	1.350	.794	4/9
Wheat (Mil. tons)	3.632	2.864	1.223	-.001	64.832	2.061*	.865	.623	.726	.935	1.604	3/9
Grain Exports												
Feed Grain (Mil. tons)	21.757	3.781	1.621	-.158	7.317	4.079*	.818	.397	.448	.650	.988	3/9
Wheat (Mil. tons)	21.327	4.702	1.752	-.639	8.758	4.987*	.708	.396	.538	.796	.812	2/9
Soybeans (Mil. tons of meal equivalence)	9.815	1.731	.918	.758	9.749	1.145*	.972	.371	.634	.657	.978	2/9
Model Average					10.983		.706	.505	1.020	1.065		2.98/9
Average of 33 Variables in this Table					16.544		.719	.535	1.029	1.144		3.15/9

*The decimal point has been shifted three places to the right in these values.

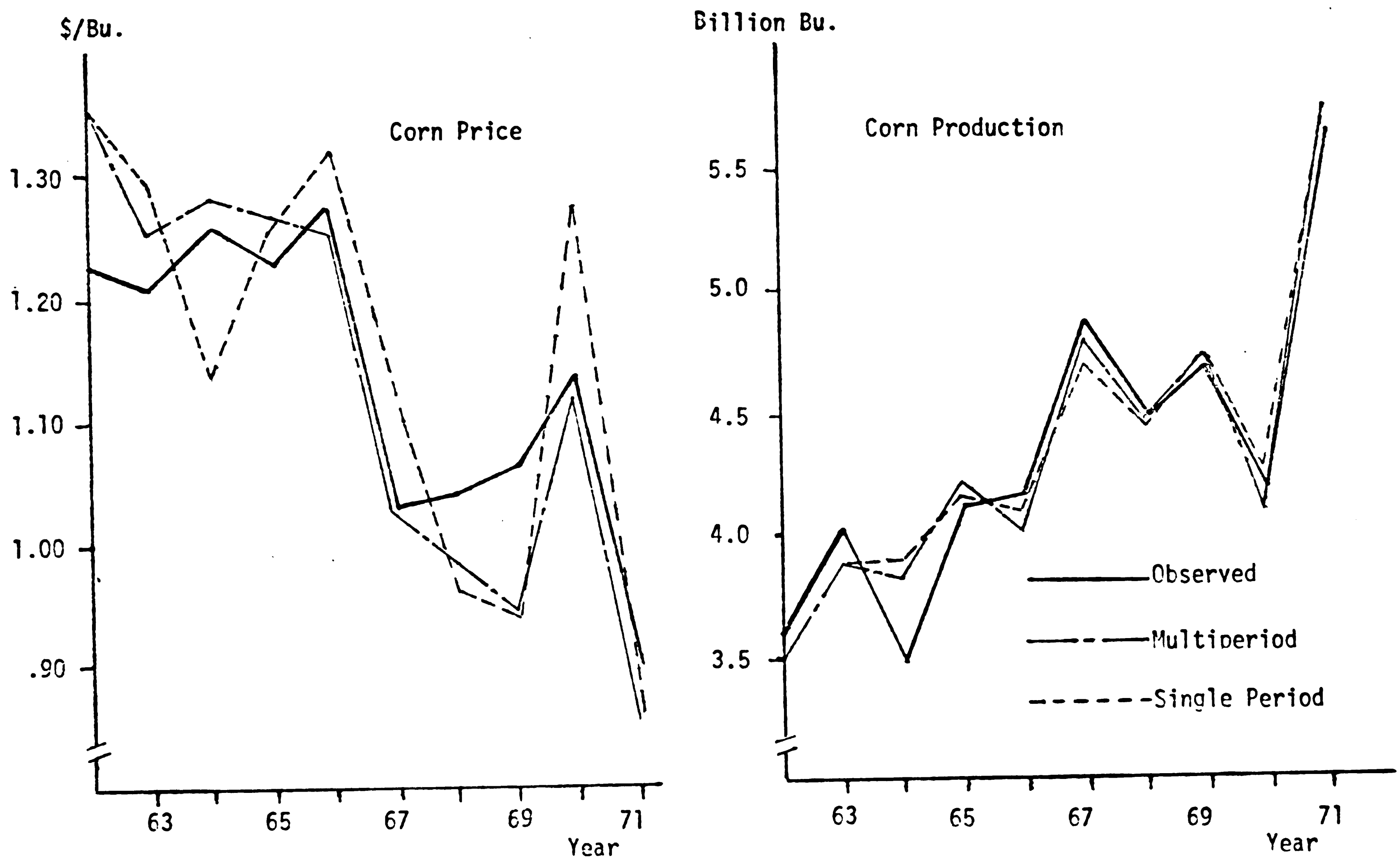

Figure V.1. Single and multiperiod *ex post* integrated model estimates for corn

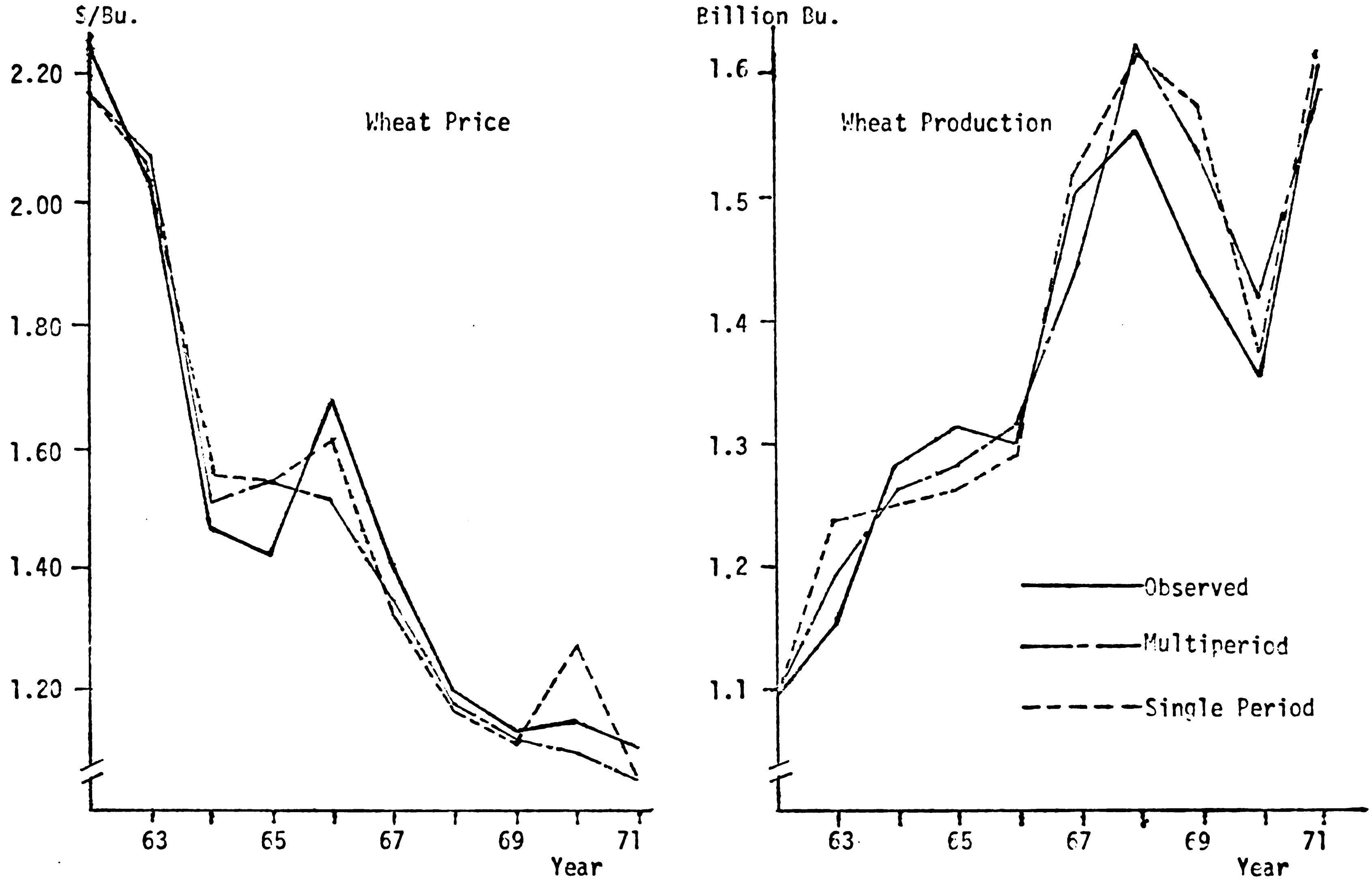

Figure V.2. Single and multiperiod *ex post* integrated model estimates for wheat

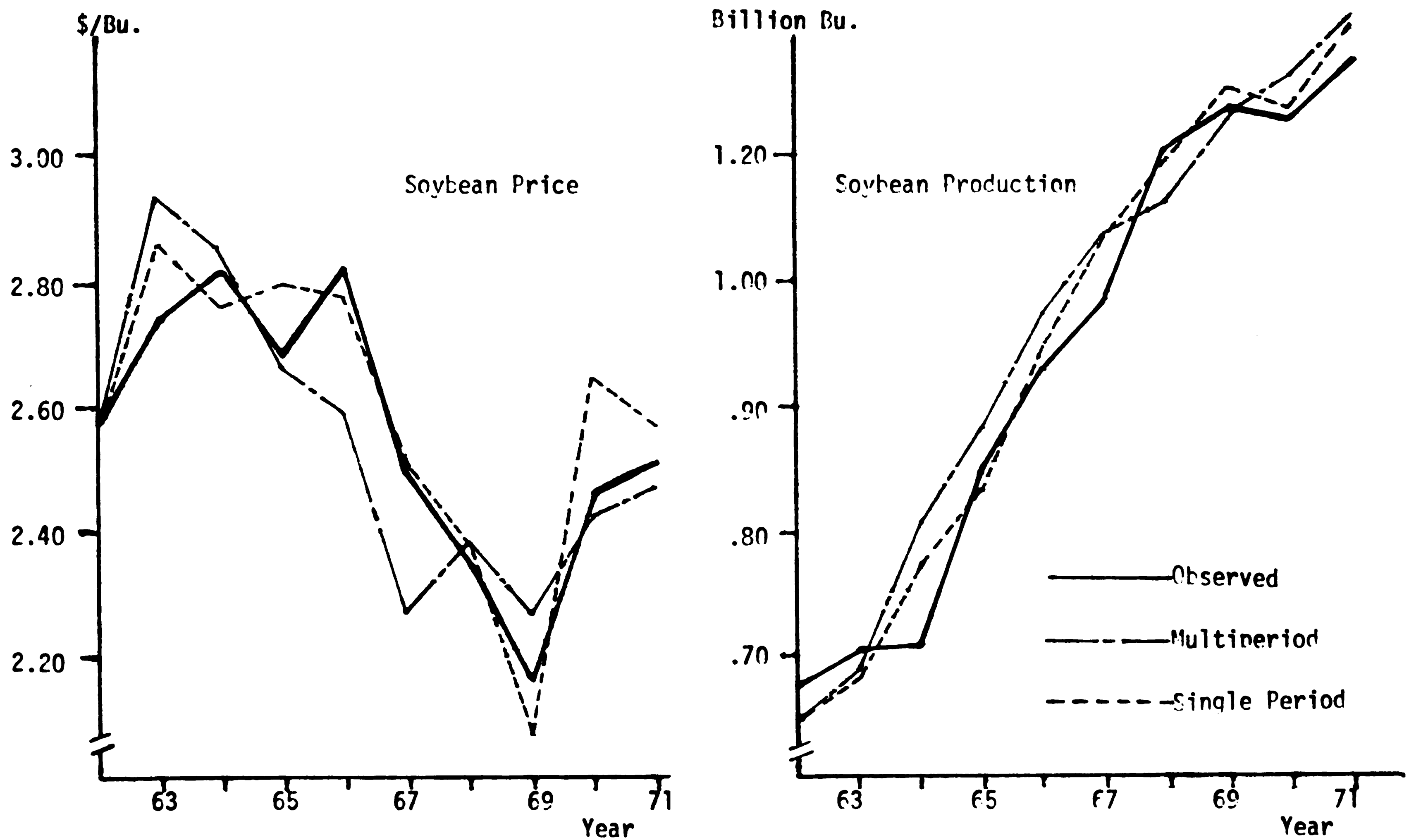

Figure V.3. Single and multiperiod ex post integrated model estimates for soybeans

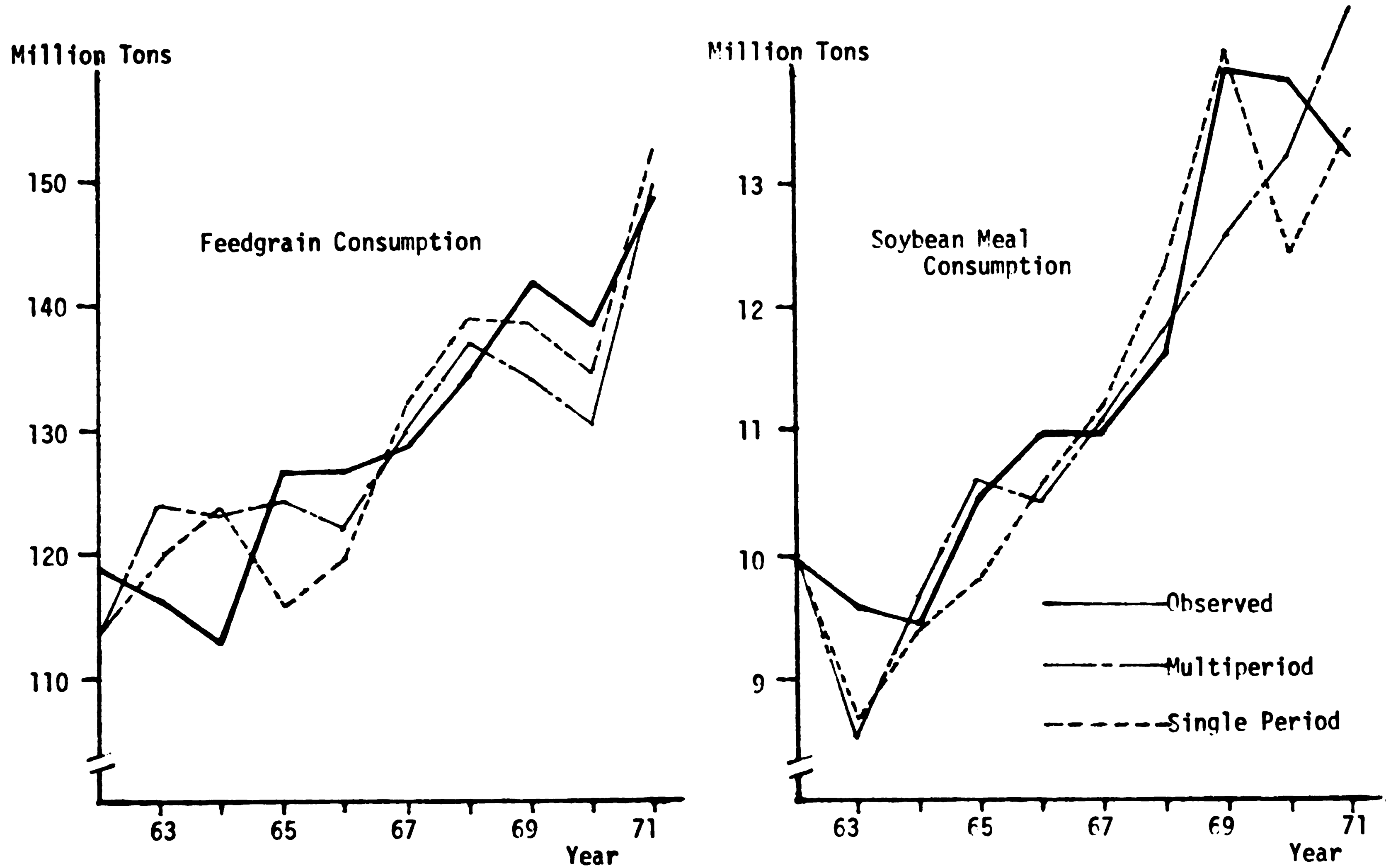

Figure V.4. Single and multiperiod _ex post_ integrated model estimates for feed constumption

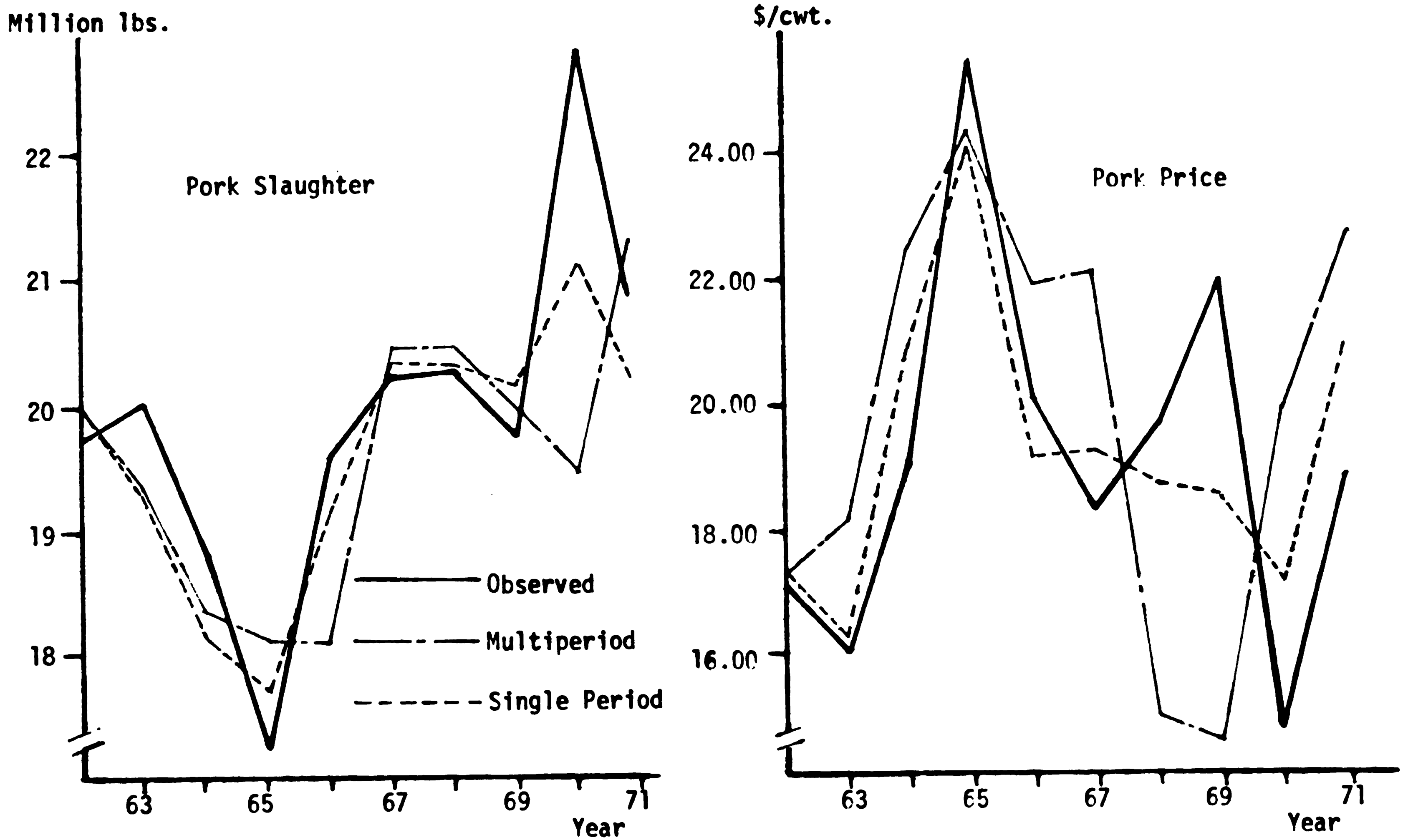

Figure V.5. Single and multiperiod <u>ex post</u> integrated model estimates for pork

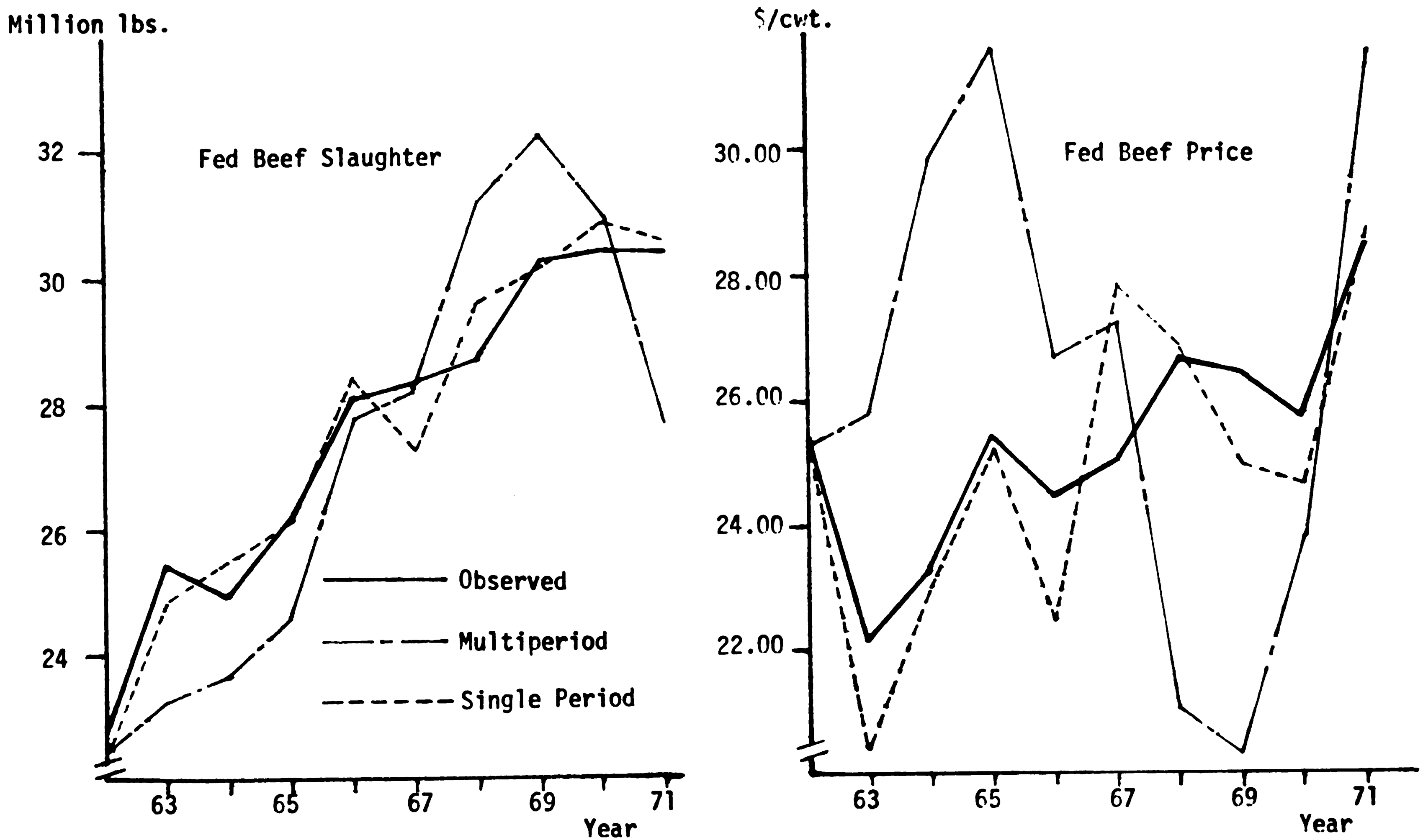

Figure V.6. Single and multiperiod <u>ex post</u> integrated model estimates for beef

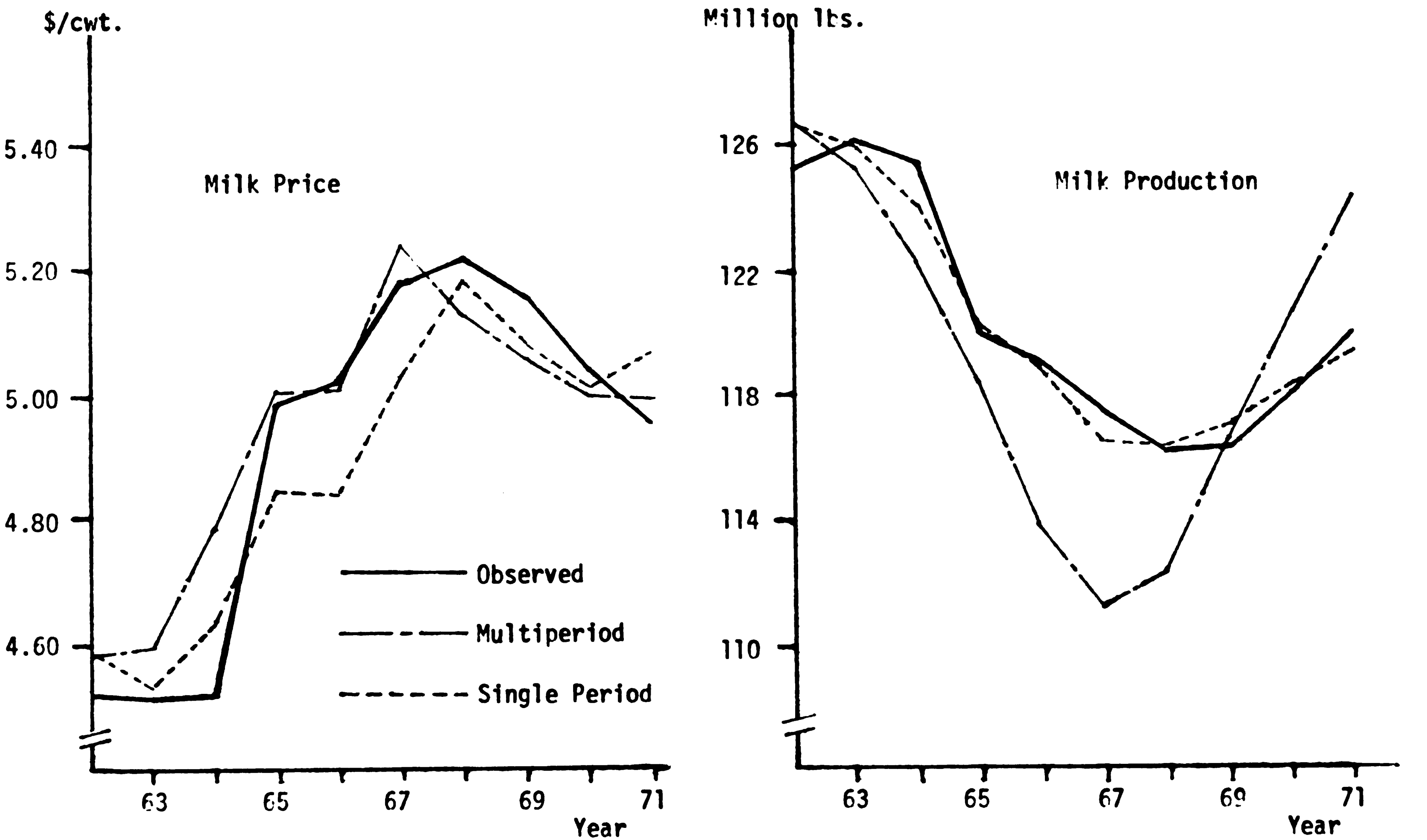

Figure V.7. Single and multiperiod ex post integrated model estimates for milk

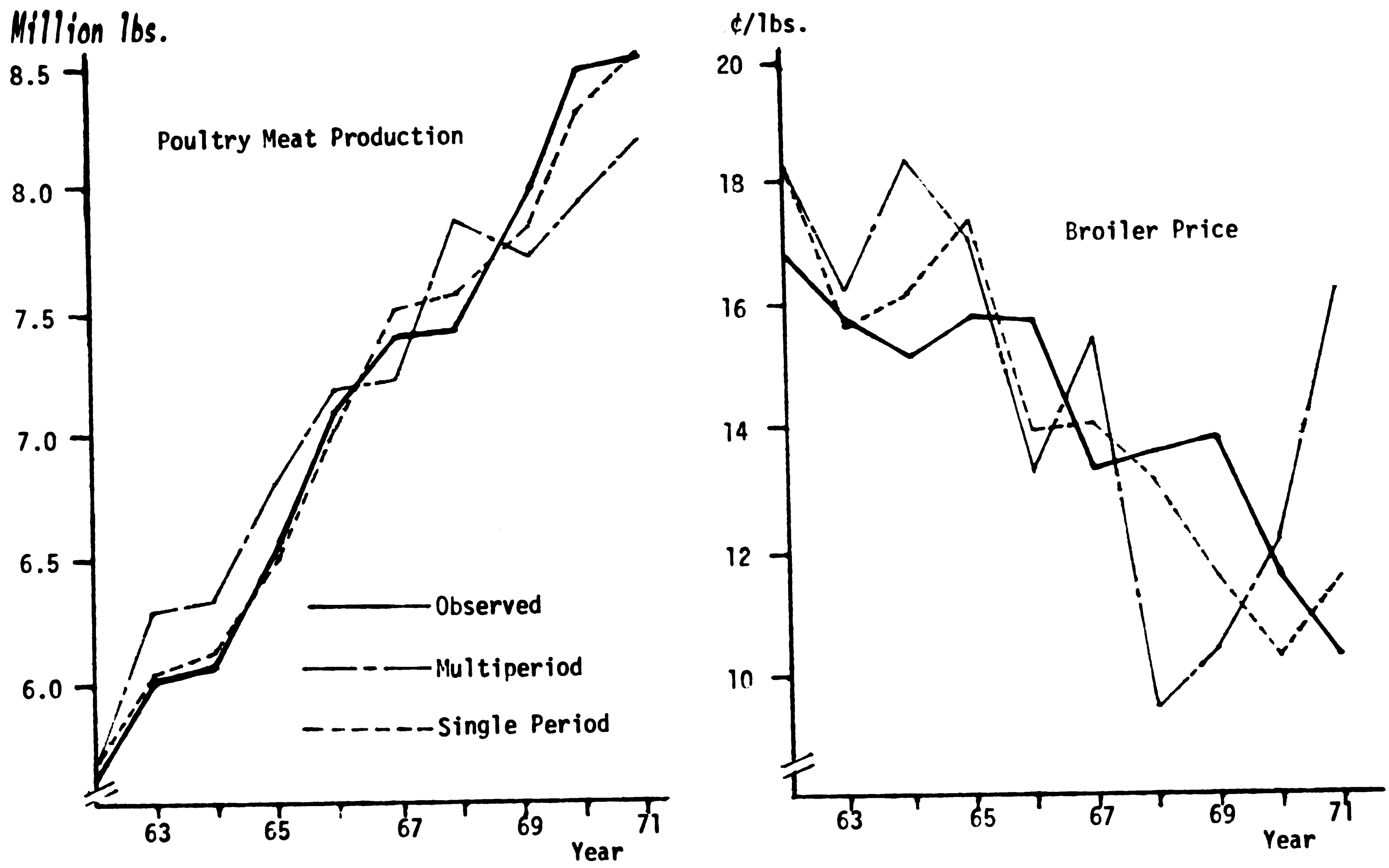

Figure V.8. Single and multiperiod *ex post* integrated model estimates for chicken

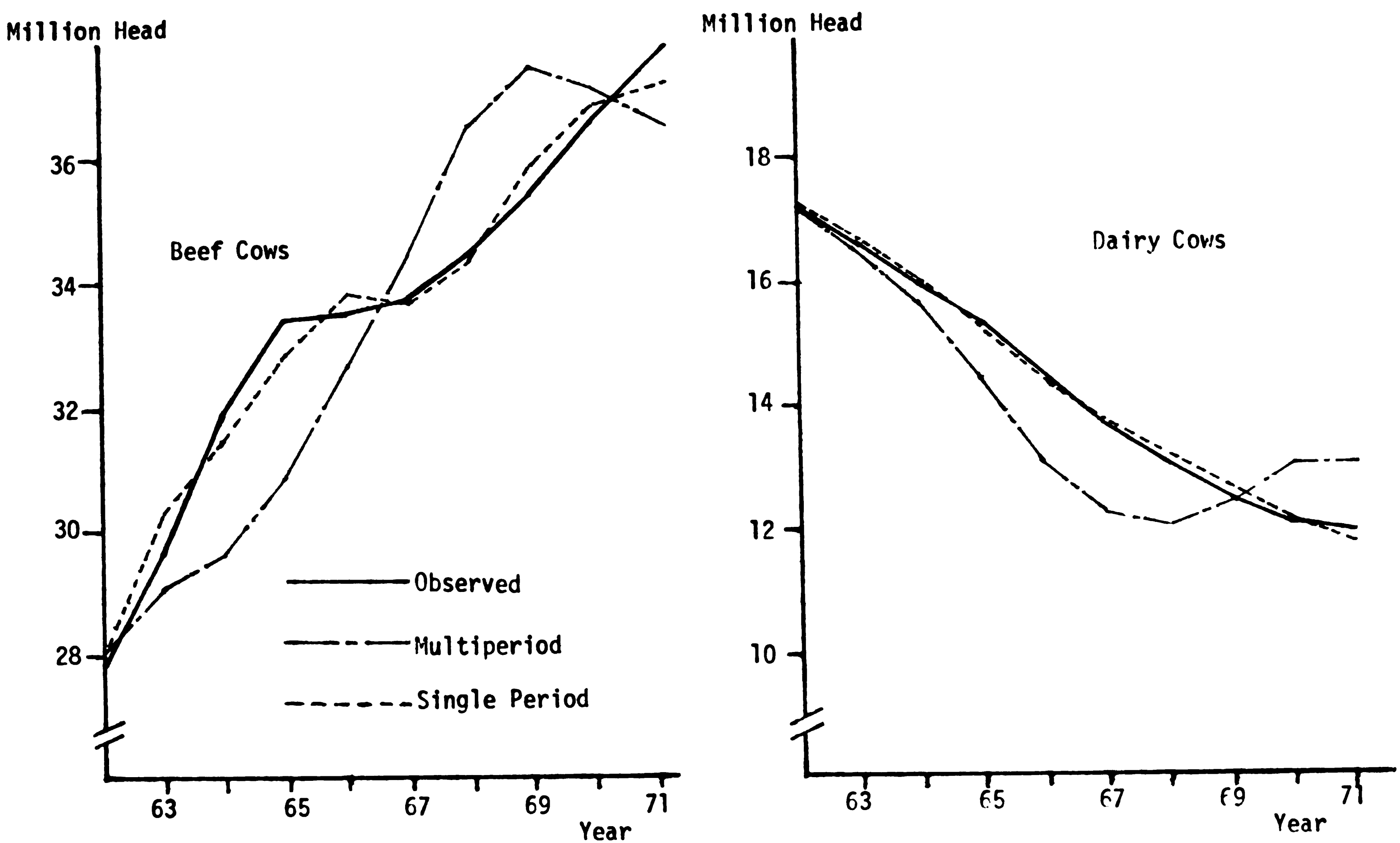

Figure V.9. Single and multiperiod ex post integrated model estimates for cow numbers

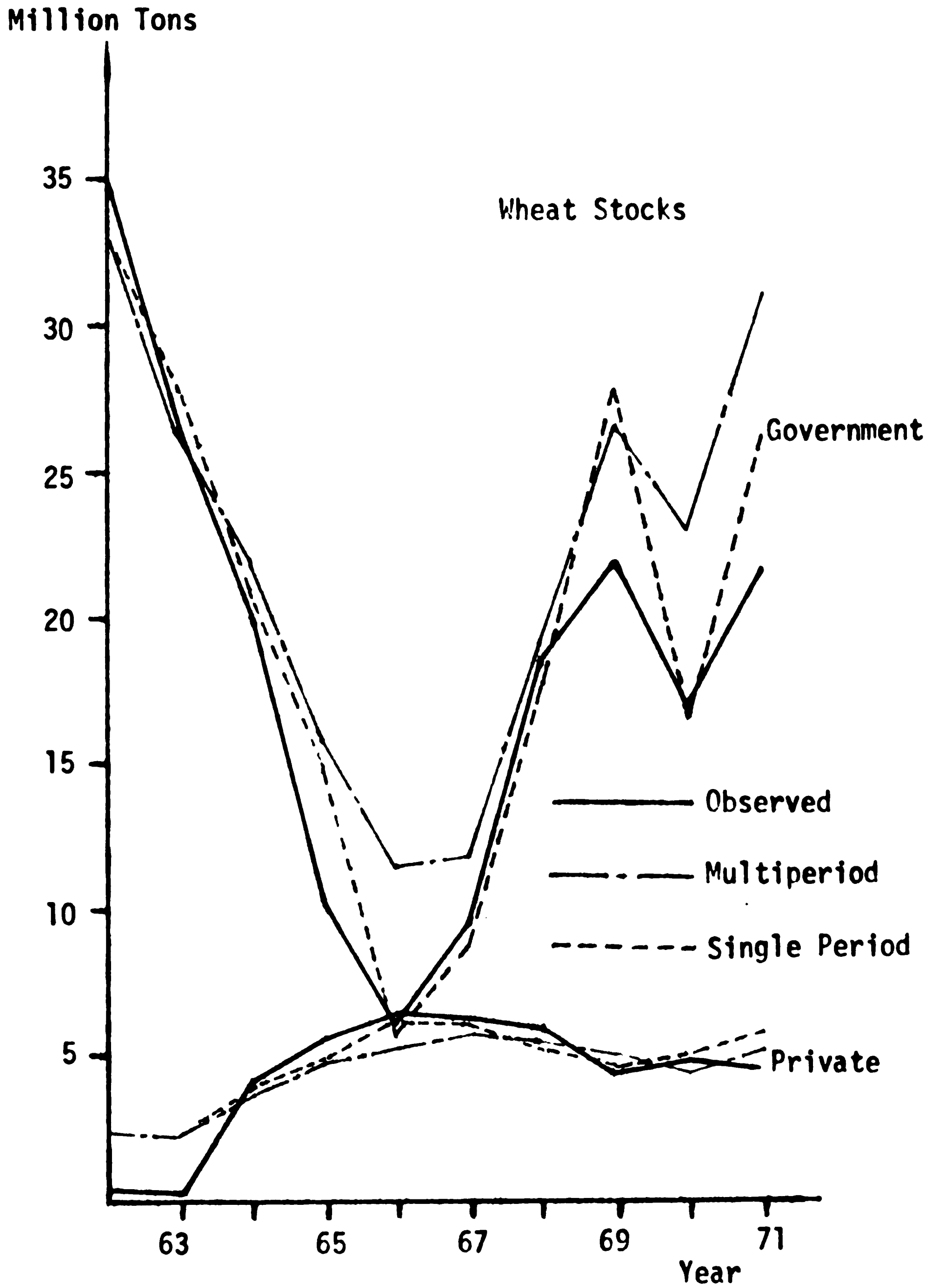

Figure V.10. Single and multiperiod <u>ex post</u> integrated model estimates for wheat stocks

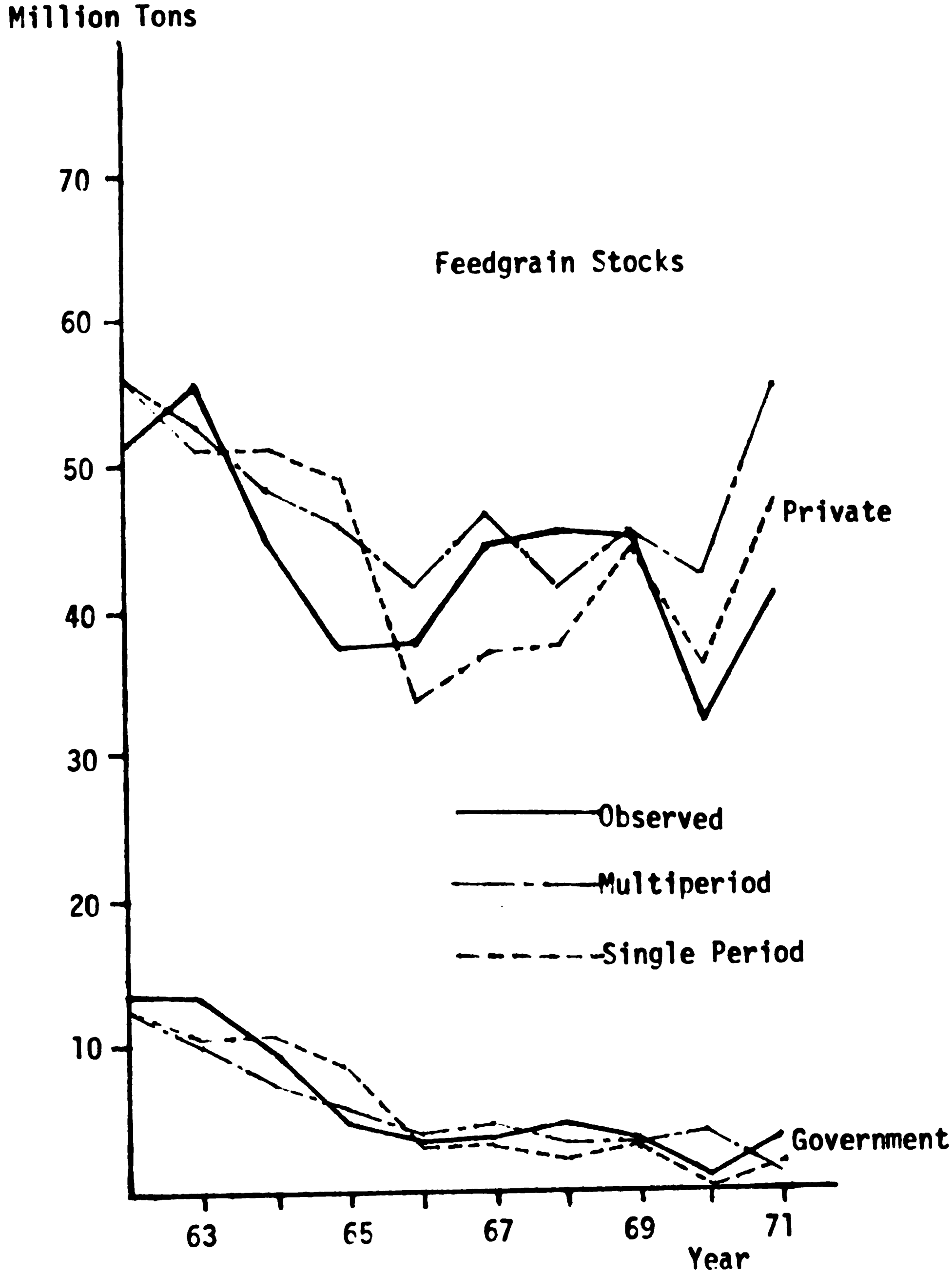

Figure V.11. Single and multiperiod *ex post* integrated model estimates for feedgrain stocks

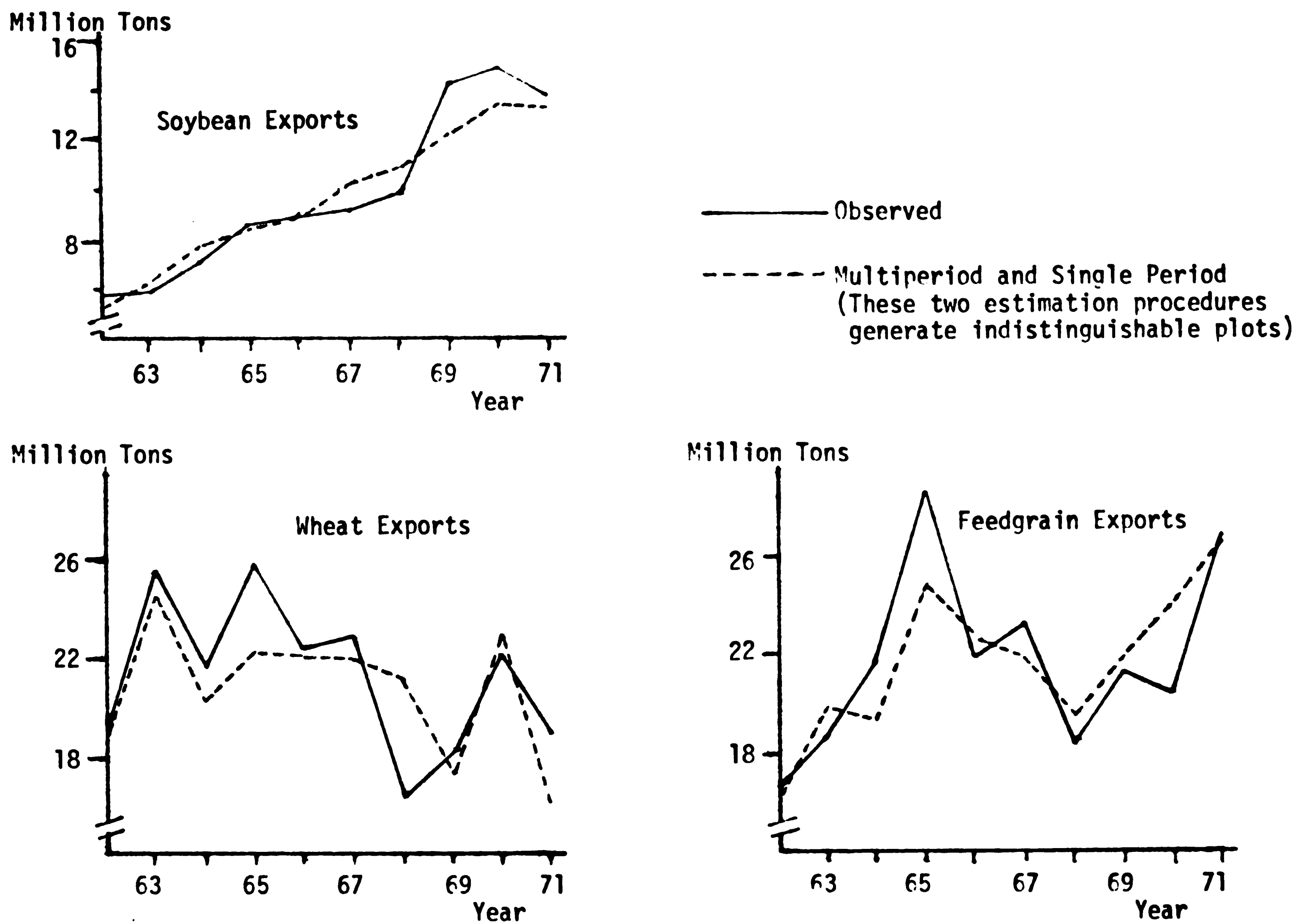

Figure V.12. Single and multiperiod <u>ex post</u> integrated model estimates of grain exports errors in stock estimates, despite their generally good R values, causes the average model estimation error of 8.68 percent to be well above the median percentage error.

Livestock and crop quantities are estimated with better accuracy in percentage terms, R values and U values, than livestock and crop prices. Several factors are believed to create this phenomena of better quantity estimates than price estimates. First, short-run demand elasticities are larger than short-run supply elasticities, hence small errors in quantity estimates lead to large price estimate errors. Second, most quantities supplied are recursively specified, thus in single period estimates all the information which supply estimates are based upon is exogenous and entered at observed values. This is not the case with price which requires estimated supply information to obtain a price estimate. In the case of grains, stocks and exports play a significant role in setting price and are difficult to estimate.

In observing the single period estimates, it is seen that total exports are estimated relatively accurately. Percentage error is from 6.8 to 8.8 percent and the naive actual variate and first difference models are inferior to the export models used for wheat, feedgrains and soybeans. (It should be recalled that the grain and soybean export models are not single equation models. Total exports are found by summing some 19 equations in the case of feedgrains and wheat, and five equations in the case of soybeans.)

Table V.3 presents the accuracy values for a 10-year multiperiod simulation. Exogenous variables which are not lagged endogenous variables, are specified at their observed values in this simulation. All lagged endogenous variables are entered at their estimated values after the initial period. This form of multi-period simulation is synonymous to a projection that could have been made in 1961 for all years up to 1971 given perfect knowledge of 25 domestic exogenous variables and all foreign populations, incomes, production levels, P.L. 480 exports and exchange rates.

Because the endogenous variables are lagged at their estimated values recursive error accumulates in the feed backloops and lag structures of the model. The equilibrium mechanism of the model causes series of serious errors which are biased in one direction to be eventually corrected. But as such errors accumulate, the path of the predictions will deviate in magnitude and turning point timing from the historically observed pattern.

In observing the multi-period estimates and comparing them to the single period estimates several points stand out. First the overall accuracy of the multi-period estimates in following the ten-year historical time path, as opposed to the accuracy of ten single period estimates, is worse but encouragingly not a great deal worse. Total average model percentage error increases from 8.685 percent to 10.983 percent. The simple correlation coefficient drops from .806 to .706. On the average .4 more turning points are missed in the ten-year multi-period estimates.

The Theil U coefficients also deteriorate. The multi-period simulation model is unable to out-perform either the naive actual variate or first difference model. The definition of these naive models should be recalled to place a proper perspective upon this inability. The naive models used in calculating U_2 and U_2A coefficients assume true knowledge of endogenous values the year immediately preceding a given forecast, a luxury the multi-period simulation model possesses only in the first year of simulation. Hence maintaining a comparable level of accuracy to these naive models over a 10-year period is assessed to be relatively good performance.

Deterioration of estimation accuracy in the ten-year multi-period simulation occurs primarily in the livestock quantity and price categories. This can be attributed to several factors. First, crop production and prices were largely controlled by policy factors during this period. These factors are exogenous to the model and hence specified at their true value. Livestock production and prices, on the other hand, are influenced relatively less by exogenous factors.

Second, livestock supply has the most complex lag structure or dynamic properties of any category of variables in the model. Therefore recursive error is most seriously reflected in the livestock supply functions. Observation of the plots of the ten-year multi-period estimates of livestock supply reveal that the path of the 10-year estimates is logical but is, after the first few periods, out of cyclical phase or slowly divergent from the true path. (See Figures VI.1-VI.12).

Surprisingly a number of the accuracy measures for the ten-year multiple period estimates of crop quantities and prices are better than the average single period estimate accuracy measures; i.e. corn quantity and price R values, inequality coefficients and percentage error terms all improve in the multi-period estimates.

Factors Affecting Model Accuracy

From the previous discussion it is evident that the accuracy with which various variables can be estimated over a historical period by this model, or any model similar to it, is dependent upon a number of factors. One is the number of periods the model is called upon to project. A second factor is the amount of information which is exogenous to the model. Lastly, the specific nature of the variables being estimated affects the model's accuracy, i.e. prices appear to be harder to predict than quantities.

The NASS model is a relatively closed system in comparison to many models. The ratio of exogenous to endogenous variables in the domestic component is quite low, i.e. only 27 of 122 current period domestic variables are exogenous. The major portion of the exogenous variables of the domestic system are policy variables for crops, of which there are in general two for each of seven crops. Other major exogenous domestic variables are population, income, interest rates, wage rates, inflation rates, fertilizer prices and weather proxies.

The model can be run with various components held inactive and the endogenous variables associated with the inactive components provided exogenously.[1] It also can be run for various multi-period

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[1] The following components which are normally endogenous can be specified as exogenous by use of programmed options; export demand; livestock supply; breeding herd levels; crop supply; yields, and acres planted. Any combination of these components can be held exogenous in a given case, i.e. a good example of an appropriate case where a combination of components might be desired to be held exogenous, is for a one-year forecast being made early in the crop year. Breeding levels and acres planted are likely to be known with great certainty and therefore would preferably be inserted exogenously. It should be (footnote continued)

simulation lengths. In general, when modifications such as these are made, the accuracy of the estimates change as expected. More accuracy is obtained over shorter multi-period simulations and with large quantities of exogenous information. However, the magnitude of improved accuracy obtained by reducing multi-period simulation length or quantity of exogenously provided information, is not great (just as the accuracy lost in going from single period estimates to 10-year multi-period estimates was small) hence the total ten-year multi-period estimation accuracy as reported in Table V.3 appears to be relatively robust in comparison to other less demanding forms of historical estimation modes.

Forecasting with the NASS Model

A limited amount of validation involving forecast outside of the sample period have been conducted with the NASS model. Forecasts have been made with the model as far forward as 1976 by exogenously specifying the level of export demand and assuming judgmental values for domestic exogenous variables when needed.[2] Table V.4 presents the observed values of the endogenous variables, when such values are available, and model forecasts of these variables.

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1 (continued)
noted that the author has observed and believes that holding a portion of the model exogenous, hampers the model's ability to readily self-correct recursively generated errors in a multi-period forecast. Hence, while tracking accuracy is improved by holding various component exogenous, realistic self-stabilizing behavior is harmed for multi-period forecasts.

[2] Exports were exogenously specified because exogenous data needed to solve the export sector of the model have not been collected beyond 1972.

Table V.4 Integrated Model Forecasts for Crops and Livestock for 1971-76

	1971		1972			1973			1974			1975			1976		
	Predicted	Actual	Unadjusted[b] Forecast	Adjusted[b] Forecast	Actual	Unadjusted[b] Forecast	Adjusted Forecast	Actual	Unadjusted[b] Forecast	Adjusted[b] Forecast	Actual	Unadjusted[b] Forecast	Adjusted[b] Forecast	Actual	Unadjusted[b] Forecast	Adjusted[b] Forecast	Actual
Crops																	
Price[a]																	
Corn ($/bu.)	1.03	1.08	1.39	1.42	1.57	1.13	1.42	2.55	1.35	1.90	2.95	1.67	3.05	--	1.50	2.17	--
Wheat ($/bu.)	1.29	1.34	1.80	1.81	1.76	1.77	1.85	3.95	1.57	4.75	4.04	1.74	1.73	--	1.93	2.47	--
Soybeans ($/bu.)	2.96	3.03	4.38	4.62	4.37	2.51	3.80	5.68	5.41	2.84	6.25	2.89	6.02	--	4.73	4.17	--
Quantity																	
Corn (bil. bu.)	5.699	5.641	5.437	5.437	5.573	5.786	5.790	5.647	6.567	4.922	4.651	6.274	4.943	--	7.155	6.037	--
Wheat (bil. bu.)	1.619	1.618	1.681	1.681	1.545	1.792	1.791	1.711	2.054	1.457	1.793	1.997	2.374	--	2.109	1.766	--
Soybean (bil. bu.)	1.204	1.176	1.276	1.276	1.276	1.626	1.448	1.547	1.245	1.301	1.233	1.617	1.109	--	1.518	1.334	--
Livestock																	
Price[a]																	
Pork ($/cwt.)	25.36	22.82	17.40	31.41	35.66	36.71	34.70	34.83	21.68	27.84	43.03	29.91	34.09	--	29.74	42.68	--
Fed Beef ($/cwt.)	34.87	34.68	15.62	38.82	43.11	34.03	46.11	40.93	29.32	44.05	38.30*	40.41	42.64	--	41.92	44.65	--
Milk ($/cwt.)	6.15	6.00	6.23	6.53	6.64	7.01	7.09	7.17	7.40	7.76	8.31	7.90	8.31	--	8.04	8.82	--
Chicken ($/cwt.)	13.93	13.70	3.61	15.12	14.10	27.13	23.78	24.20	.46	11.81	21.50	25.73	19.57	--	20.24	30.48	--
Quantity																	
Pork (bil. lbs.)	20.404	20.887	19.331	19.331	18.805	18.073	20.707	19.902	21.449	22.484	17.457	23.107	20.321	--	22.470	19.587	--
Fed Beef (bil. lbs.)	30.614	30.454	38.883	30.454	29.336	33.963	30.454	30.927	36.243	31.954	--	32.660	33.454	--	35.032	34.954	--
Milk (bil. lbs.)	119.539	120.069	119.340	119.340	116.505	118.886	115.632	114.752	119.022	111.076	115.076	122.892	109.635	--	126.645	107.936	--
Chicken (bil. lbs.)	8.503	8.504	8.718	8.718	8.889	7.485	8.341	8.750	9.974	9.447	8.919	8.678	9.766	--	9.888	8.246	

[a] Nominal Prices

[b] The term adjusted versus unadjusted refers to alterations performed to consider: 1) Price freeze effects; 2) Poor yeilds in 1974; 3) The problem of linear extrapolation outside the historical data range.

Two types of forecast were made beyond 1971. The set of forecasts referred to as "unadjusted forecasts", were derived by running the model in a normal manner specifying all exogenous values at observed deterministic values for 1972,73, and 74, and providing judgmental exogenous values for 1975 and 76 where observation is not yet possible.[1] This forecast approach obtains only limited success. Crop price and quantity forecast are reasonable in 1972. The only turning point missed occurred for wheat production. Livestock quantity forecast for 1972 are all in the proper direction and of reasonable magnitude except beef production which is greatly in error. The large error in forecasting the quantity of beef produced causes all livestock prices to be under estimated in the unadjusted forecasts. In subsequent periods crop production forecasts tend to be too high and thus crop price forecasts low. Likewise the beef production forecasts continue to be in error thereby increasing the number of improper price signals in the livestock sector and generating further error in the livestock sector forecasts.

The question is asked, what went wrong in the previous set of forecasts? More specifically, what events may have occurred that the model and the provided exogenous variables might not be expected to reflect?

The first event that readily comes to mind is the price freeze

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[1]Of considerable interest and effect are the levels of judgmental export values specified for 75 and 76. They were as follows in millions of tons.

	75	76
Wheat Exports	36.0	38.9
Feedgrain Exports	50.2	54.7
Soybean Exports	23.8	26.2

and the manner in which the freeze was released in the fall of 1973. Price freeze restrictions for all agricultural products except beef were released in August of 1973. The release of the freeze had been anticipated for some time. Hence beef slaughter was reduced noticeably in July and was further reduced through August and September when the freeze on beef prices was discriminatingly retained and others were released. This causes a considerable shift in beef slaughter timing. A large amount of beef that would have been slaughtered in crop year 1972 (ending September 30, 1973) was shifted into the 1973 crop year.

A second event occurring between 1972 and 1976 that the model is only weakly capable of predicting was a general drop in yields during the 1974 crop year. Weather variables currently used in the model are not capable of precisely reflecting the impact of weather on yields.

The general surge in agricultural prices that occurred in 1972 and 1973 are historically unprecendented. Thus the model might be expected to over-react to such price increases given its linear specification.

In light of the three observed conditions just discussed three adjustments were invoked upon the model. First, the beef model was rendered inactive in 1972 and 73 when price freeze effects were present. A naive no-change model was substituted for the beef model. Second, 1974 yields were entered exogenously at true values. Lastly, expansion of acres planted of any crop was restricted to 12 percent growth in any single year. With these adjustments imposed, a new set of forecasts (labeled "adjusted forecasts" in Table V.4) were made.

The three adjustments imposed are minimal in terms of coping with the 1972-75 period of change occurring in U.S. agriculture. The foreign component of the model is inactive and export levels are specified exogenously in the forecasts being made here.

Invoking the three adjustments causes improved performance relative to the unadjusted forecast. Figures V.13 to V.16 show the tracking and '71-76 forecasts for the "adjusted forecast" set. With a few exceptions for tracking for '72 through '74 appears equivalent to the 1962-71 tracking ability.[1] Crop production levels are forecast surprisingly well with the possible exception of wheat. Livestock production forecasts to 1974 are also in the proper direction and of comparable magnitude with reality, with the noteworthy exception of pork production in 1974. Price forecasts are less satisfactory in the case of livestock and crops, but still bear a resemblance to reality particularly for 1972.

With regard to the adjusted 1975 and 1976 forecasts, it should be recalled that these forecasts are being made from a 1971 base with no updating or correction of the prediction error of the lagged endogenous variables after 1971. No structural changes were made to the model except the three aforementioned. Reestimation and restructuring of the model to take account of knowledge provided by the 1972-74 experiences would likely render more reliable forecasts

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[1] Accuracy measures of this tracking period were not calculated since data needed to do so are not coded.

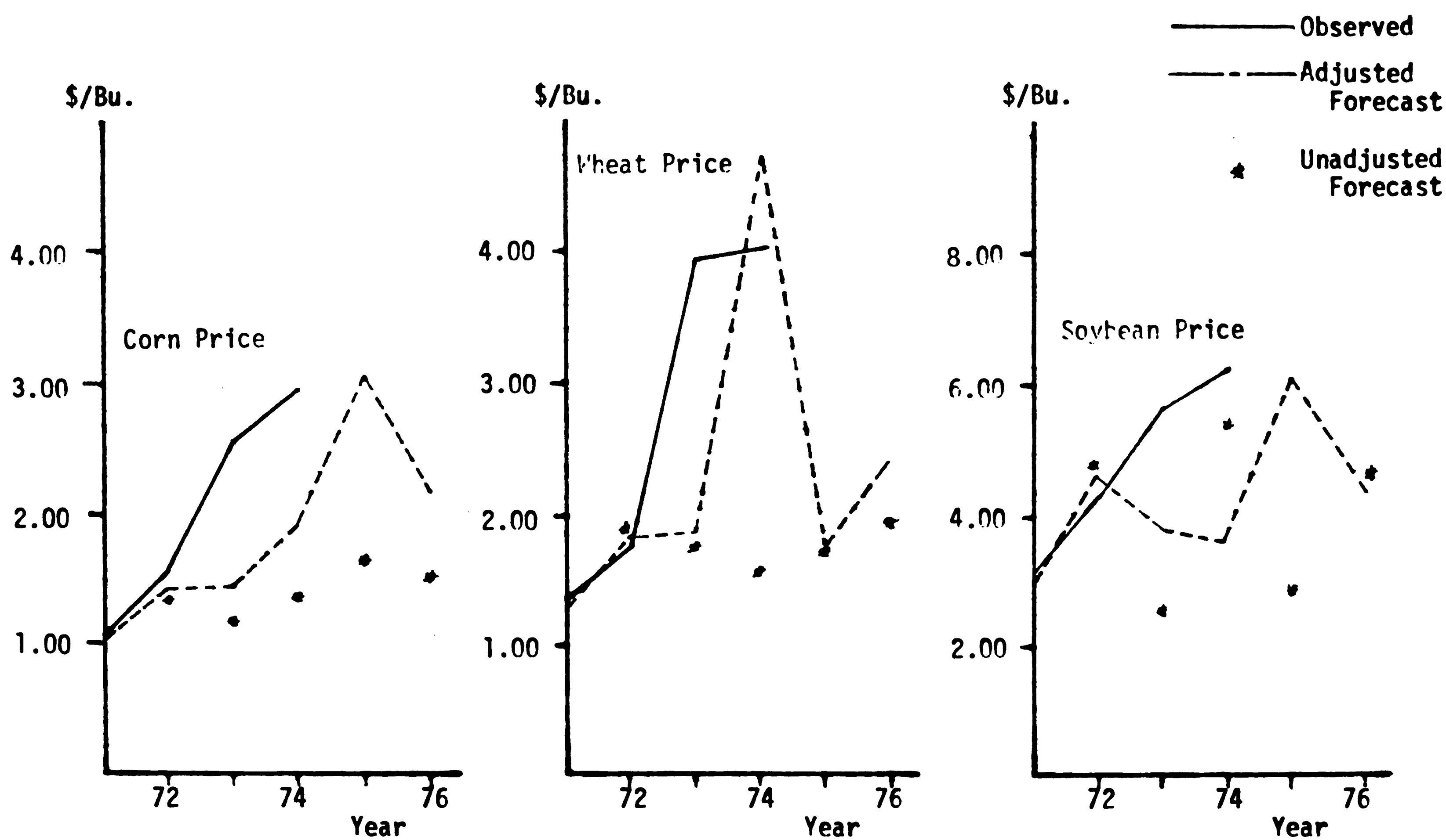

Figure V.13. Crop price forecasts and observed values for 1971-1976

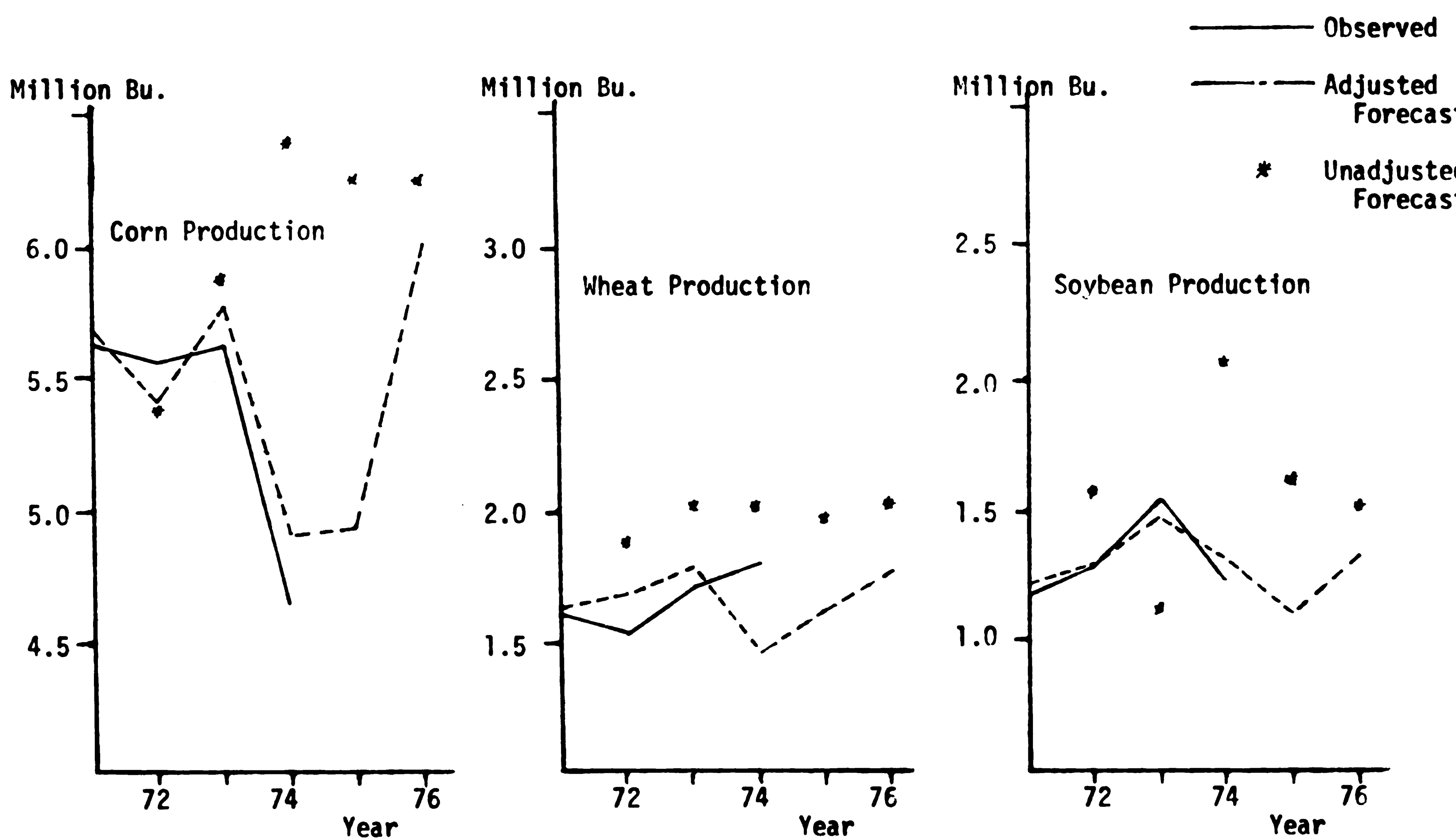

Figure V.14. Crop production forecasts and observed values for 1971-1976

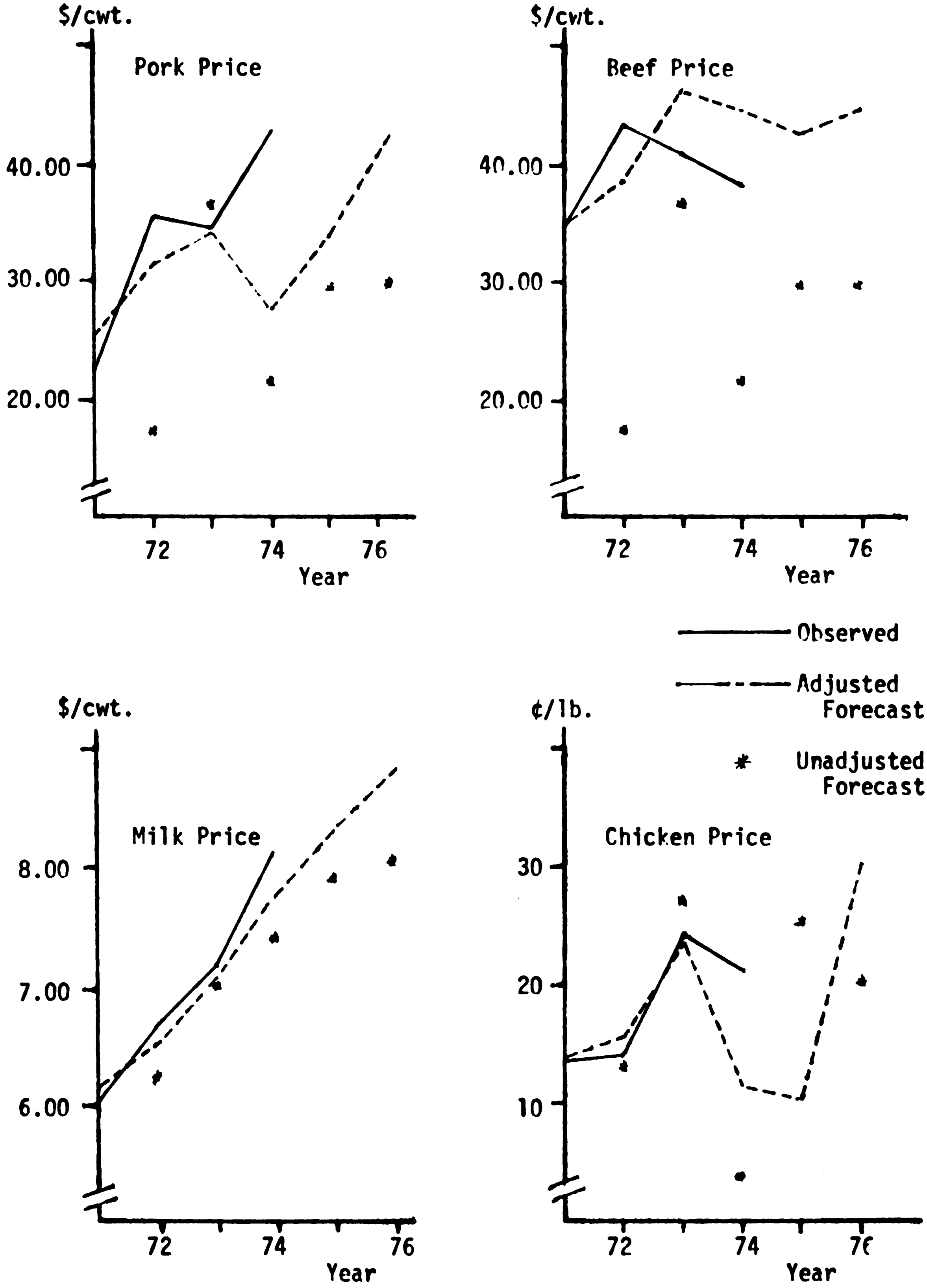

Figure V.15. Livestock price forecasts and observed values for 1971-1976

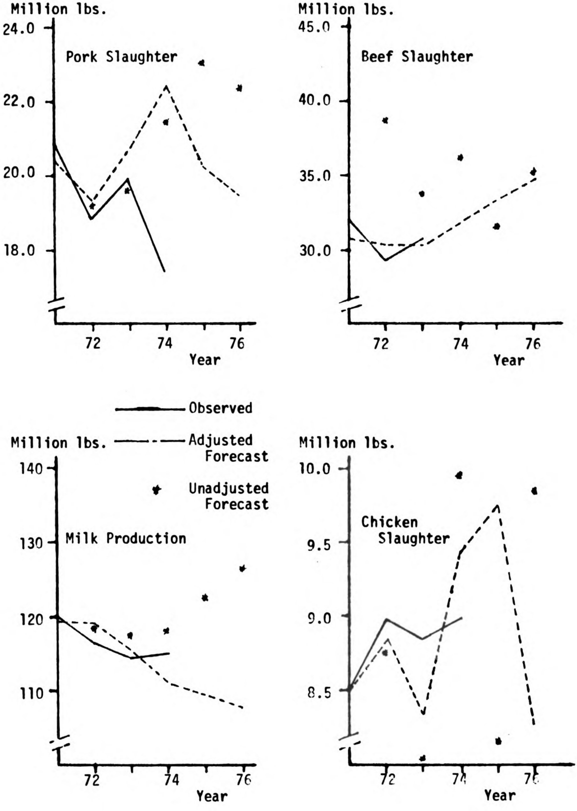

Figure V.16. Livestock production forecasts and observed values for 1971-1976 for the 1975 and 1976 crop years. Nevertheless the 1975 and 76 crop year forecast stand as feasible possibilities when viewed at this point in time. The mere ability of the model to make a feasible post data period prediction five years beyond its base period with limited modifications imposed upon the model, is felt to lend support to the basic validity of the model's abstract representation of the agricultural sector.

The ability of the domestic sector of the NASS model to generate predictions which resemble the '72-74 actual agricultural sector behavior are felt to lend some support to the hypothesis that structural change within the agriculture sector may not have been large during 1972-74. Rather most of the unprecedented changes in agricultural prices observed during this period have been due to unusual exogenous shocks; i.e. export growth, inflation, price freezes, weather, non-agriculturally produced input prices, etc.

Dynamic Properties of the NASS Model

Agricultural economists have historically observed that certain dynamic patterns of response occur. The most widely discussed of these is the "pork cycle" and various other livestock cyclical patterns. If these observations are true, a realistic model should generate such cycles. To ascertain if such cyclical tendencies exist, all "shock" factors or shifts in exogenous conditions have to be removed. In the previous tracking runs, various trends and single period shifts in exogenous factors created enough "noise" in the system that any cyclical properties, if they existed, were largely "covered up" by continual occurrences of exogenous shocks.

In order to observe the relatively "undisturbed" cyclical tendencies of the model, a 50 year steady state run was conducted. Steady state is defined as holding all exogenous variables constant at some specified level. The endogenous components are allowed to interact and all endogenous feedback loops and simultaneous interactions continue to function. Observation of the time paths of the endogenous variables under such steady state conditions will reveal the inherent cyclical, or trend properties of the endogenous components.

Observation of the time path of endogenous livestock output variables for a 50-year steady state run reveals that cyclical patterns are produced. Figure V.17 shows the cyclical pork quantity and price patterns generated in the 50-year run. Both the price and quantity cycle are five years in length. This is one year longer than perhaps is a priori expected.

The cycle lengths for all livestock products were approximately five to six years in length. The cycles however were not "in phase", i.e. they peaked at somewhat random periods in relation to each other.

The pork cycle is the most pronounced of any of the livestock cycles in terms of amplitude. The difference between a given high point in the cycle and the following low point of the pork supply cycle is typically about 14 percent of the high point value. For example, between the 21st and 24th steady state iteration, pork production falls from 21,855 million pounds to 18,749 million pounds. This magnitude of oscillation is not extreme in comparison to

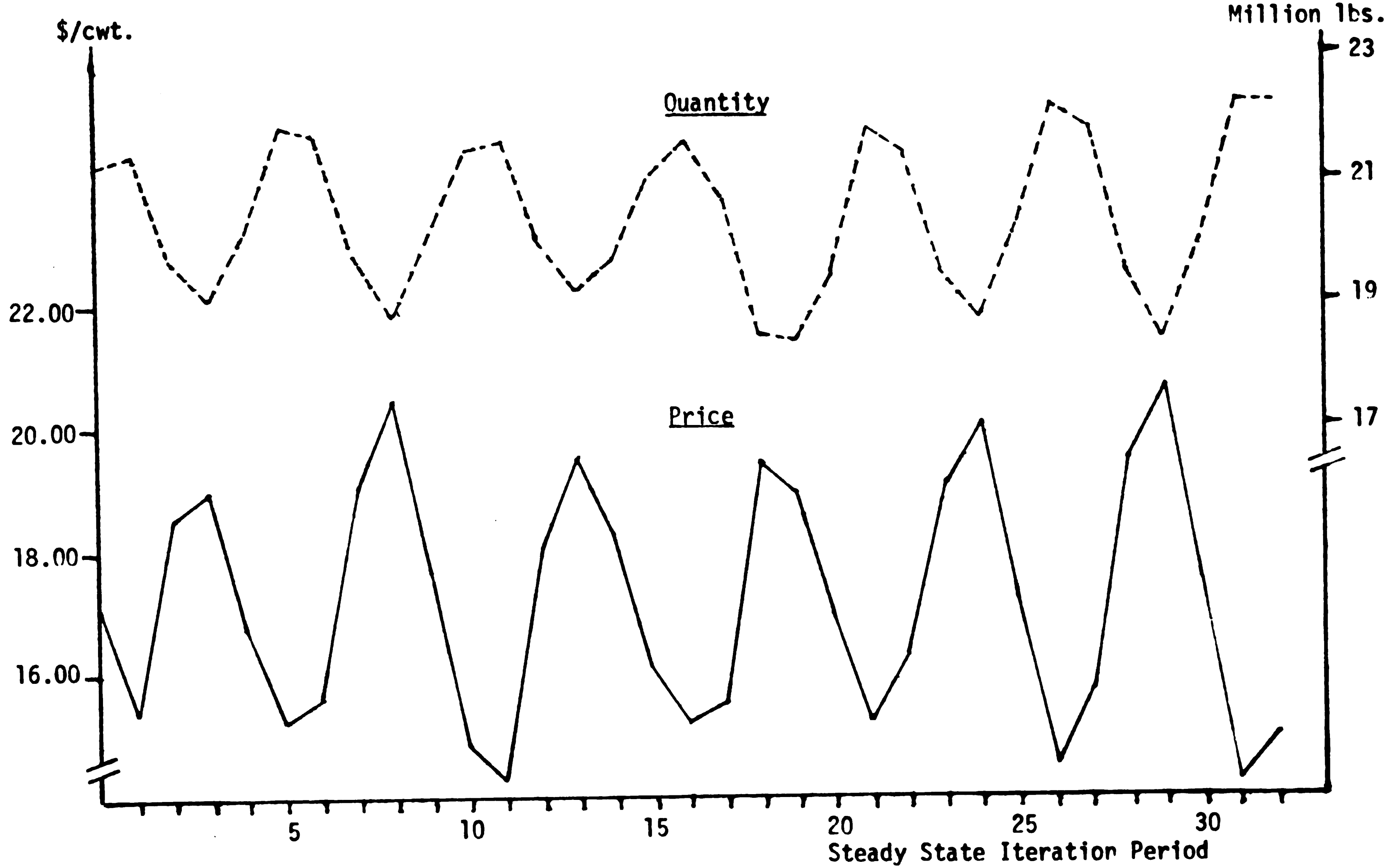

Figure V.17. Pork price and quantity cycles historical oscillations in pork production. From 1963 to 1965, pork production fell from 20,019 million pounds to 17,208 million pounds or approximately 14 percent. Pork production then rose to 20,447 million pounds by 1969.

Cyclical oscillation is also present and regular in simulated production of other livestock products, but the magnitude of oscillation is much less. In the case of fed beef a comparable percentage decline from the high to low point of a cycle is approximately 3.4 percent. For other livestock supply and inventory categories comparable percentage declines are as follows: non-fed beef 2.3 percent, beef cow numbers .7 percent, dairy cow numbers 2.4 percent, chicken meat 1.2 percent, eggs .2 percent and turkey 1.7 percent.

In observing the simulated cycles for pork and other livestock categories, it is apparent that the steady state cycles generated are slightly explosive in nature, that is their amplitude continues to increase instead of decrease.[1] One can debate whether or not U.S. agricultural livestock production activities are inherently stable or unstable. In general, economic theory implies that an

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[1]If one represents a set of equations comprising an econometric model in matrix form as follows:

$$Y_E = AY_t + BX_t + U_t$$

where Y_t = a vector of endogenous variables
X_t = a vector of exogenous variables
U_t = a vector of error terms
A = a matrix of parameters
B = a matrix of parameters

the stability of the system can be determined by examining the properties of the A matrix. Examination of the characteristic roots of the A matrix will indicate whether the system will generate cyclical or non-cyclical patterns and whether the system is explosive or convergent. Alternatively the stability of the system can be observed by running the model in steady state. The later approach is used here.

economy is cyclically stable and converges to an equilibrium value if exogenous factors do not continually keep changing and create shifts in the supply and demand relations.

Perhaps a more serious question than whether the model is demonstrating the proper degree of dampening or explosiveness of cycles in the livestock sector is whether the observed cycles are of the proper length. As previously states all simulated livestock price and quantity cycles demonstrate a length of five to six periods. The pork cycle is generally believed to be shorter than this and the beef cycle is felt to be longer. (Poultry and diary cycles have not readily been observed historically or discussed in the literature.)

A priori expectation of the integrated model's dynamic properties were that beef and dairy cycles would be longer than pork cycles since the lag structure in the beef and dairy supply response models were longer.[1] The existence of one common cycle length for all livestock in the model may perhaps be explained by interaction between livestock cycles and the dominance of the pork cycle. As previously reported the degree of oscillation in the pork cycle is by far the largest of any of the livestock supplies. Pork also is the dominant source of demand for feedgrains and protein feeds, typically demanding approximately one-third of the corn and about one-fourth of the high protein feeds consumed by livestock. Also pork

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[1]It is interesting to note that Freebairn and Rausser observed a simulated average beef cycle length of 5.4 years in a dynamic livestock sector model which they developed and reported in an article entitled "Effects of Changes in the Level of U.S. Beef Imports," American Journal of Agricultural Economics, Vol. 57 (November 1975).

provides about one-third of the per capita red meat supplies in the U.S.

The importance of pork in the agricultural sector coupled with its relatively large cyclical amplitudes may cause it to "pull" other factors along with it by generating and sending systematic endogenous shocks into other components of the model that are strong enough to generate similar cycles in these components. If this were the case one might expect all cycles to eventually fall into phase with the pork cycle. This is not the observed case for other livestock supply cycles in the 50-year steady state run. However it is observed that a cyclical pattern exists for corn which is in phase with the pork supply cycle. (See Figure V.18).

After approximately 14 time periods, corn production and price fall into a steady five-year cycle. In comparing corn and pork cycles generated by the model several points are of interest. First, the corn price and quantity cycles are not the precise inverse of each other as is the case with pork (and in general all livestock) i.e. price does not peak when quantity bottoms. The pork quantity cycle and corn price cycle are "syncronized," or in phase, in that corn price peaks in the same period as pork quantity. Specifically both corn price and pork price peak in the 16th, 21st, 26th, 31st period, etc. The syncronization of the corn price and pork quantity cycles lends support to the hypothesis that the pork cycle is a dominant cycle in the model and generates endogenous systematic shocks that create other similar cycles in the system. The study of cycle interfaces and cross-effects in a multi-livestock commodity model appears to be a potentially interesting subject.

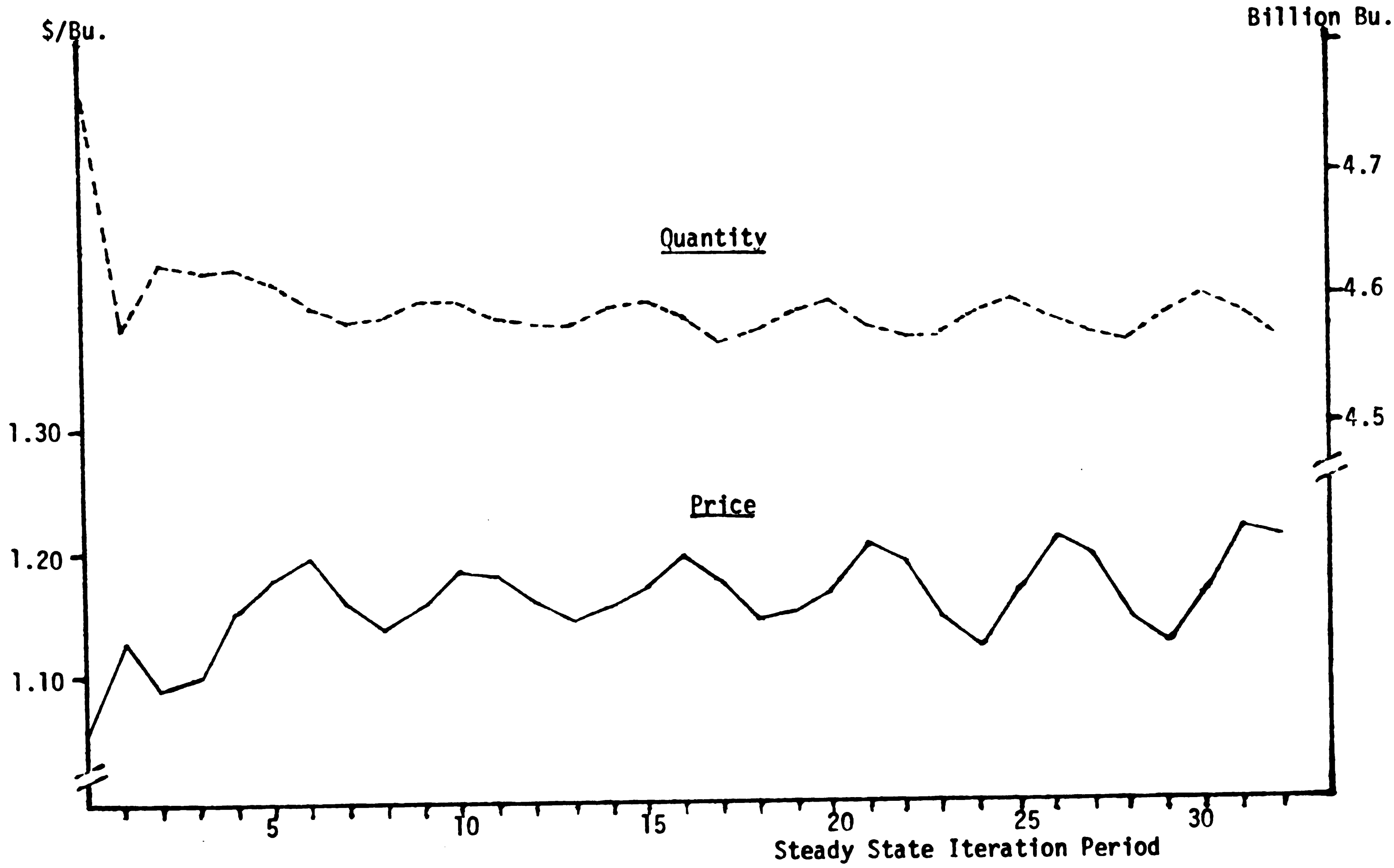

Figure V.18. Corn price and quantity cycles

As has been alluded to, corn price and quantity display cyclical tendencies in the 50-year steady state run. Five-year cycles are also observed for wheat and soybean prices and quantities in this steady state run.

It should be noted that if support prices for wheat, corn or soybeans are set above the minimum value of the price cycles for each respective crop, the crop price cycles are disturbed by government action. If support prices are set high enough in all crops, prices and production levels become constant. Government stock accumulations then become explosive with cyclical patterns present in the feedgrain soybean stock path due to the continued existence of cycles in the livestock sector which generates cycles in feedgrain and soymeal demand.

Cross Consistency Checks

Several consistency questions can be asked with respect to the solution values of the model. Such consistency checks can lend added validity to the model. Examples of consistency checks include; how reasonable are the implied feed consumption rates per animal? are the implied per capita human consumption of food grain and meat reasonable? are growth rates within historically observed or logical bounds? etc. These consistency checks relate integrated predictions by several portions of the model.

The model prints a number of integrated summary statistics at the end of each solution interaction which can serve as logical cross model consistency checks. Among this set of information are feedgrain consumption rates for livestock. These rates are in general observed to be quite reasonable in both absolute and relative terms. For example, the feedgrain consumption rates calculated for the last year of the ten-year multi-period simulation run previously presented are as shown below. Rates are expressed as grain consumed per pound of product produced, except in the case of eggs where the rate is in terms of grain consumed per dozen eggs produced.

Category	Feedgrain Consumption Rate
Pork	4.36
Fed Beef	2.67
Milk	.31
Chicken	2.13
Eggs	5.32
Turkey	3.86
All meats	3.06

The consumption figures for fed beef and milk do not include an allowance for the breeding herd but all other categories do. The "all meats" figure of 3.06 pounds of meat is low relative to the often stated seven pounds of grain per pound of meat ratio because no grain equivalents for protein feeds or roughages consumed have been added. Roughage, in the form of hay, and other harvested forage and pasture when expressed in corn equivalents, were estimated to have provided 53 percent of all feed consumed in 1971 according to the USDA Livestock Feed Relationships Bulletin. High protein feeds and other by-product feeds expressed in corn equivalents were similarly estimated to provide 11 percent of all feed consumed. Thus in corn equivalent terms approximately 64 percent of all feed consumed by all livestock in 1971 was of non-grain origin. Converting the 3.06 pound figure on this basis yields an indicated 9.0 pounds of total grain equivalent consumption per pound of meat produced. Hence the consumption rate per pound of meat appears perhaps high but reasonable. In addition, the relative rates appear as expected; i.e. beef and dairy which are roughage intensive categories, have low consumption rates as does poultry -- a very efficient user of gain with a relatively protein intensive ration.

Estimated human consumption for the last period of the ten-year multi-forecast period implies the following per capita consumption rates in pounds, or dozens as is the case with eggs.

Category	Human Per Capita Consumption
Pork	104.72
Fed Beef	134.60
Milk	604.80
Chicken	39.81
Eggs	27.67
Turkey	8.86
All meat	335.53
Wheat	152.63

In evaluating these figures, it should be recalled that they are in terms of liveweight or ready-to-cook basis, in the case of turkey and chicken, and wheat in grain form. With this in mind it is believed that the rates are reasonable.

Lastly, the question might be asked, what is the implied total feedgrain and protein feed cost in relation to the value of livestock products output? The cost estimates for the period in consideration are $5,315 million of feedgrain and $1,354 million of high protein feed or a combined cost of $6,669 million for all livestock. The total value of livestock products output for all categories is $21,607 million. The ratio of feed cost to total value is approximately one to three, which appears reasonable.

The last year of the ten-year multi-period forecast run was picked for these comparisons since the manner in which it was estimated would permit a substantial amount of inconsistency due to cumulative recursive error. No significant cross model inconsistencies however were found. In other observed prediction periods, no extremely illogical cross consistency measure were observed either. Hence it is felt that the model satisfies the criteria of integrated consistency.

CHAPTER VI

SENSITIVITY ANALYSIS: RESULTS AND APPLICATIONS

In this chapter the simulated response to changes in several exogenous variables will be described. The description and analysis of simulated responses to exogenous "shocks" serve both as further information in validating[1] the model, to provide insight needed for policy analysis and for making economic projections.

Methods of Conducting and Interpreting "Shock" Responses

The sensitivity analysis to be conducted here consists of changing exogenous variables or sets of variables -- i.e. "shocking" the system for a given time period, and measuring the magnitudes and durations of response generated for the simulated values of the endogenous variables. In order to conduct such an analysis three factors must be defined: 1) the base from which change is made, 2) the base to which responses are compared, and 3) the response measures. The context and nature of these definitions have important implications for subsequent use of the information derived from the analysis.

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[1]Validation and continual development of the model are closely related processes. Knowledge gained about the magnitude or sensitivity of the model to various shocks will point out weaknesses, strengths and areas within the model critical to good performance of the integrated model.

Economists commonly use the concept of elasticity to measure the response of a dependent variable to a change in a given independent variable. The concept of an elasticity (or flexibility) can be expanded to describe and measure responses in a system of dynamic equations to a change in a given independent variable. In the context of a dynamic system this response measure is referred to as a dynamic multiplier.

A dynamic multiplier is defined as the effect of a one-period change in the level of an exogenous variable on the time-path of values of an endogenous variable. More specifically, a period multiplier is given by dY_{t+r}/dX_t where Y_{t+r} denotes an endogenous variable in period t+r with $r = 0,1,\ldots,$ and X_t denotes an exogenous variable in period t.[1] When $r = 0$, the multiplier is called an impact multiplier describing the current period or short-term effect of a change in x on y. For $r > 0$, the multiplier is called an interim multiplier describing the effect on y in period $t + r$ of a change in X in period t. The equilibrium or long-term multiplier effect of a change in x on y is given by $\sum_{r=0}^{\infty} dY_{t+r}/dX_t$.

The concept of a dynamic multiplier though similar differs from the traditional elasticity concept. Since elasticities are generally calculated by taking partial derivatives of an individual function with respect to a given variable, all other exogenous and endogenous factors are theoretically held constant and dynamic

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[1]J.W. Freebarin and Gordon C. Rausser, "Effects of Changes in the Level of U.S. Beef Imports." American Journal of Agricultural Economics 57 (November, 1975): 676-688.

interaction is not allowed. The elasticity is interpreted as a long-run or total response change since full establishment of a new equilibrium is assumed to occur in one period. In various single equation distributed lag models the dynamics of response (with all other interdependencies held constant) tend to be considered and reported in the context of "short" and "long-" run elasticities.

In computing dynamics multipliers only the variables exogenous to the entire system are held constants. Hence the interdependencies between various endogenous variables are allowed to influence the determination of the magnitude, pattern and duration of dynamic multipliers. In a dynamic model the impact of change in any exogenous variable can be traced through the system to every endogenous variable, and a dynamic multiplier can be calculated for each endogenous variable. The study of dynamic multipliers generated by various controllable exogenous policy variables can yield valuable insight into policy questions.

Dynamic multipliers generated by change in an exogenous variable can be mathematically solved for provided the model is a linear model and contains certain stability properties[1]. Alternatively, dynamic multipliers can be numerically obtained from simulation output of systems which contain nonlinear equations and/or perhaps long distributed lags.

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[1]Dynamic Multiplier can theoretically be determined mathematically for a linear system by proceeding as follows. Define:

A and B as matrices of coefficients

Y_t as a vector of endogenous variables

X_t as a vector of exogenous variables

V_t as a vector of errors

t as representing time and t-r as time in previous periods (i).

(footnote continued)

To numerically obtain estimates of dynamic multipliers equivalent to mathematically calculated dynamic multipliers, several conditions must be met. First the model must be run in "steady state" until a long-run equilibrium solution is found.[2] The model can then be "shocked" and the divergence from the equilibrium levels observed and used to calculate dynamic multipliers.

Figure VI.1 shows the plots of a steady state base run for the variables wheat price and wheat quantities (shown in solid lines). Note that the base run plots exhibit erratic behavior for some five to ten periods after the steady state run is started. This is due to various components of the model continuing to adjust from shocks

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1 (continued)

With complete generability of the lag structure the econometric system can be represented as follows:

$$Y_t = AY_t + BX_t + U_t$$

This is a difference equation which (subject to certain constraints) may be solved to obtain the final form of the model:

$$Y_t = A^t Y_{.0} + BX_t + ABX_{t-1} \dots + A^{y-i} BX_{t-i}$$

This final form can be used, in turn, to derive the various dynamic multipliers. (The procedure for doing this is discussed in Theil's "Principal of Econometrics" or Goldberger's "Econometric Theory." Both texts are published by John Wiley and Sons.)

Examination of the estimated characteristic roots of the A matrix in the above defined system will indicate whether the system will generate a convergent deterministic system or explosive system. The magnitude of the dominant roots will also indicate the speed at which the system converges or explodes. If the system is unstable long-run dynamic multipliers will be equal to a negative or positive infinity.

[2]Steady state is defined as holding all exogenous variables constant and repeatedly solving the model, allowing only the endogenously generated lagged variables to change from solution iteration to solution iteration. A long-run equilibrium solution is found by repeatedly solving the model in a steady state mode until repeated iterations yield identical solution values for all endogenous variables. If the model is not stable such a "steady state" solution or long-run equilibrium cannot be obtained.

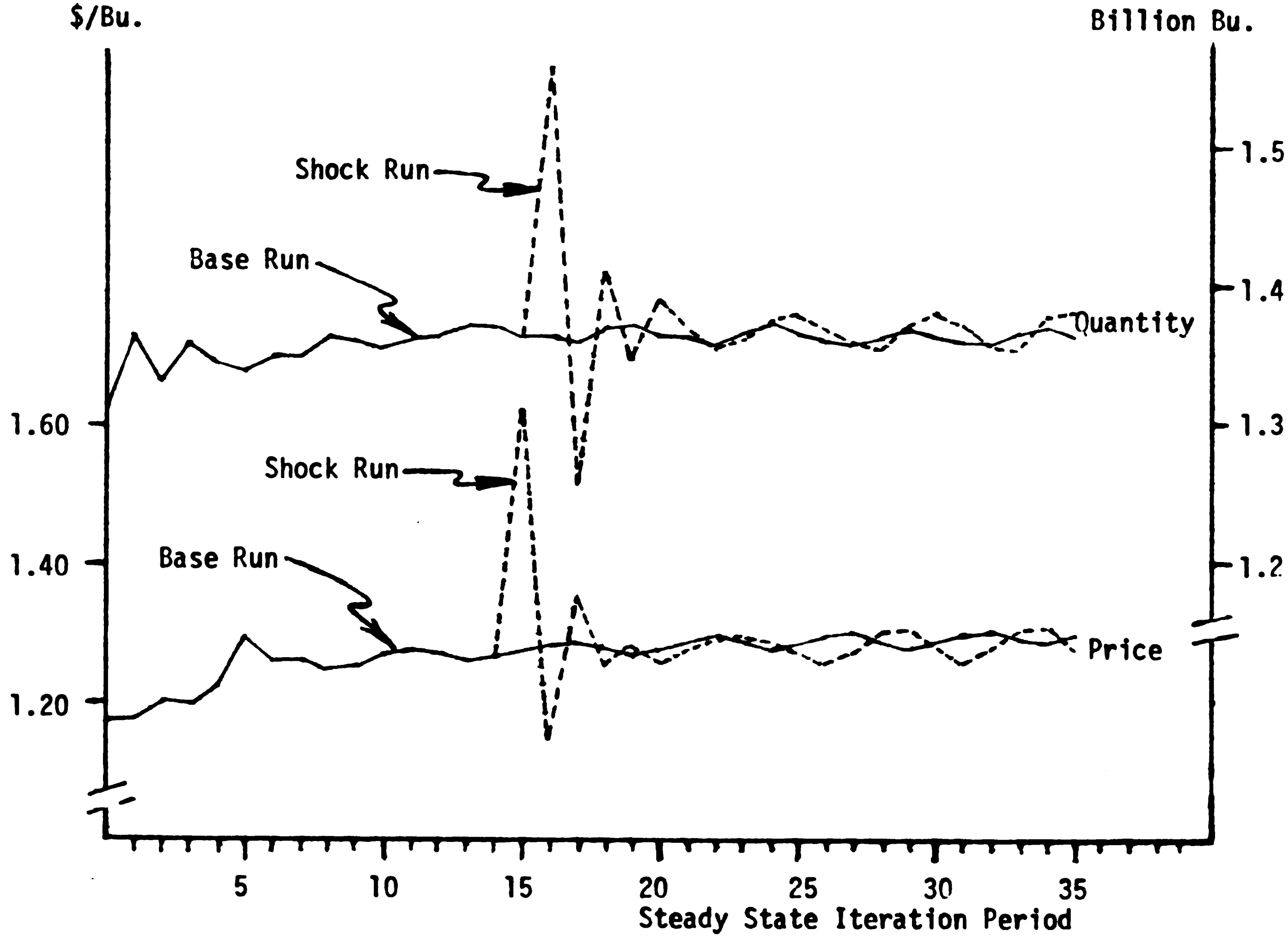

Figure VI.1. Wheat price and quantity shock response initially contained in various lag structures of the model. Hence erratic movement toward an equilibrium state is demonstrated by all interrelated endogenous variables until the lagged effect of previous shocks have cleared the system.

In the case of the NASS model absolutely constant values of all endogenous variables are never obtained during the steady state run, rather slight oscillation about some constant mean value continues throughout the run.

The path of endogenous values obtained from the steady state run provides a base from which to compare the path of endogenous values simulated in a second run, the so-called "shock run." The shock run begins the same period as the steady state base run, and the same initial and subsequent exogenous value are provided. However, in the 15th period of the shock run, depicted in Figure VI.1 by the dotted line, the exogenous value for wheat export purchases (representing communist bloc wheat purchases) was increased by five million tons or 22.6 percent. This shock was injected for one period only and hence is referred to as an "impulse shock."

The response to the shock is immediate for wheat prices. Table VI.1 indicates (and Figure VI.1 illustrates) that in period 0, the period of the shock, wheat price rises 36.1 cents above the base run value or to 28.4 percent above the base value. The short-run elasticity of response (one-year response) is estimated to be 1.256.

Since wheat supply is fixed in the period of the shock, no response in wheat supply can occur. In the period following the shock, however, wheat production is simulated to increase by 19,224

Table VI.1 Dynamic Response Measures of a 5 Million Ton Wheat Export Shock[a]

	Short-Run Impact Multiplier	Interim Multipliers							Long-Term[b] Multiplier
	0	1	2	3	4	5	6	7	15 i=1
Wheat Price									
Difference[c]	+ 36.100	- 13.700	+ 6.400	- 1.900	+ 1.800	- 1.400	- 1.600	- .200	+ 25.000
% Difference[d]	+ .284	- .107	+ .050	- .015	+ .014	- .011	- .012	- .015	+ .196
Cumulative % Difference	+ .284	+ .177	+ .227	+ .212	+ .226	+ .215	+ .203	+ .201	+ .196
Period Elasticity	+ 1.256	- .473	+ .220	- .066	+ .063	- .049	- .054	- .007	+ .866
Cumulative Elasticity	+ 1.256	+ .783	+ 1.003	+ .937	+ 1.000	+ .951	+ .897	+ .890	+ .866
Wheat Quantity									
Difference[c]	.000	+ 19224.000	-11103.000	+ 6148.000	-2193.000	+ 2117.000	+ 489.000	+335.000	+ 15630.000
% Difference[d]	.000	+ .414	- .181	+ .045	- .016	+ .016	+ .004	+ .003	+ .114
Cumulative % Difference	.000	+ .141	+ .059	+ .105	+ .089	+ .104	+ .108	+ .110	+ .114
Period Elasticity	.000	+ .622	- .359	+ .200	- .071	+ .069	+ .016	+ .011	.504
Cumulative Elasticity	.000	.622	.263	.463	.392	.461	.477	.488	.504

[a] A five million ton shock constitutes in this case a .226 percent increase in wheat exports for a single period followed by a return to normal exogenous wheat export levels.

[b] Cumulative values are not summed as symbolically indicated since they are sums by definition.

[c] Difference refers to the difference between the steady state base run and shock run and is calculated by "shock run value" - "base run value".

[d] Difference (as described in C) as a percent of the base run value.

bushels above the base run value. This is a 14.1 percent increase in production which implies a short-run elasticity of .622 for wheat production.

Figure VI.1 and Table VI.1 show that following the impulse shock the response pattern generated is of an oscillatory nature and dampening. Nearly all of the oscillatory response has ended approximately seven periods after the shock. As evidence of this the cumulative percentage difference between the base and shock run values for wheat price and wheat quantity are .201 and .110 respectively in period seven. In the 15th period after the shock these same figures or measures have hardly changed; they are .196 and .114 respectively. The cumulative percentage differences over 15 periods imply long-run elasticities of .866 for wheat price and .504 for wheat quantity.

Dynamic multipliers for other endogenous variables could also be obtained for this shock in a similar manner. In subsequent analyses of other "shocks", multipliers are calculated and sector wide response analyses are conducted.

Mathematically determined long-term multipliers are theoretically determined by summation to infinity. When simulation results are used to obtain numerical approximations of mathematically defined long-term dynamic multiplier, some finite period after which no significant response appears to remain must be selected. In this case and other cases where the model has been used to numerically approximate long-term multipliers it would appear that very little bias occurred in approximating the true theoretical concept of a long-term multiplier. All long-term multipliers reported here are simulated 15 period numerical approximations.

A second discrepancy generated by numerical approximations of dynamic multipliers is failure to achieve complete long-run equilibrium before imposing the shock. In the case previously illustrated, wheat price and quantity were still fluctuating by some one to two percent when the shock was imposed. This does little harm to the dynamic multiplier concept if differences are figured from the steady state base run path of values as opposed to a constant base value, say the value of the steady state base run endogenous variable at the time of the shock.

The conceptual requirements of obtaining a dynamic multiplier appear to be met whether the model is in equilibrium or disequilibrium. These requirements (as interpreted by the author) are that all factors be held as equal as possible so that a comparison between an unshocked and shocked run can be made. However, the dynamic multipliers derived will be somewhat different depending upon the period in which the steady state run of the model is shocked. This results because the position of the endogenous variables is different in every period when the model is not in equilibrium.

For example, the endogenously determined level of wheat stocks can have a significant effect upon the response of wheat price when an exogenous increase in wheat demand is specified. If stocks are large and can be liquidated to cover the exogenous increase in demand, very little price response will be generated.

The preceding conditions are not advanced as a condemnation of the process of obtaining numerical approximations of dynamic multipliers from a model in disequilibrium but as a factor to be recognized.

It is the author's belief that mathematically determined dynamic multipliers also suffer some of the same problems alluded to here. This belief bears some elaboration.

Dynamic multipliers when calculated mathematically or by any means are dependent upon the structure and conditions present and represented in the model at the time of the shock. An equilibrium state is one special set of conditions in a given structure, one that in reality never exists. Given a set of exogenous conditions only one unique equilibrium exists for a properly defined model and only one unique path to this equilibrium exists. In a different structure or set of initial conditions, a different path and end equilibrium will result. The dynamic multipliers derived from a shock to a given equilibrium state will differ from those for a shock to any other equilibrium. Hence, the derivation of a mathematically determined multiplier is arbitrary and does not yield an all unvarying general dynamic multiplier value.

This is analogous to the fact that elasticity of demand will not be the same at the mean price and quantity of a linear demand function as at other values of price and quantity. The mean is only a convenient and standard value from which to calculate the elasticity. This is also the case for dynamic multipliers calculated from the equilibrium associated with a set of initial conditions with all exogenous values set at their mean value. Hence, measures of dynamic response to be meaningful must define their basis of comparison, form of shock and measure of comparison, as was suggested at the outset of this section.

For policy analysis dynamic multipliers determined from equilibrium conditions and mean values of the exogenous variables, while informative, are not the most useful. A more useful set of multipliers would be obtained by examining the model's response when it is in a state of disequilibrium and responding to initial conditions most reflective of those at the time policy makers are considering a policy action. The policy maker should use the model to predict and analyze the change a certain policy will cause under initial conditions in effect when the policy is implemented. This is precisely what a private forecaster would do to evaluate a proposed policy change. He would forecast the change from a given base forecast where no policy changes are simulated. Such comparative forecasts would be of greater assistance to the policy maker than knowledge of dynamic multipliers based on equilibrium conditions.

An additional step can be taken to make the comparative forecast more useful to public or private policy makers. This involves specifying the most relevant initial conditions, as previously done, and a scenario of realistic changes in the conditions assumed in the base run, as opposed to holding the exogenous conditions constant. The shock run could then be made using the same initial conditions and scenarios, but injecting the shock as desired in order to study the response in a comparative manner.

Policy analysis done in this manner is felt to be the most useful and becomes nothing more or less than comparative forecasting. As such it is subject to the same problems as forecasting, i.e. the accuracy of the comparisons are affected by the following:

1. Model error

   The model can only approximate (not duplicate) the responses of the historical real world from which it is developed.

2. Structural change

   Changes in economic structure, unless anticipated and measured, will lead to different actual events than predicted by the model.

3. Errors in exogenous variable forecast

   The subjectively determined future scenario values of exogenous variables, if wrong, will lead to forecasting error.

The problem of eliminating modeling error in forecasting or conducting policy analysis is clearly the responsibility of the modeler. The problems of anticipating structural change and properly forecasting exogenous variables requires interaction between the modeler and the user. Many exogenous variables are controllable variables and forecasting them is a matter of the policy maker and/or society deciding where to set them.

Having made these observations and remarks with regard to dynamic multipliers, this study will proceed to calculate and present dynamic multipliers using as initial conditions, the values of exogenous variables existing in this model's approximation of the 1971 crop year. This is the last year of the historical data period in which the model was estimated. Steady state runs will be made from the initial conditions to provide the base values for comparison. It is realized that some value, in terms of policy interpretation of responses to shocks may be lost due to a lack of realistic exogenous scenarios and due to the use of outdated initial conditions. However the sole purpose of conducting this base-shock run comparative analysis is not for providing policy interpretations but to provide continued validation of the model. Realistic policy evaluation requires dealing with points number two and three of the list of sources of forecasting error, structural change and exogenous variable scenario errors. At this point the concern is with possible invalid model structure leading to model error. Policy implications which can be drawn in this validation process will be commented upon. It should be noted that in order to avoid slandering the concept of a true theoretical dynamic multiplier, all measures of dynamic response (using the basic concept of dynamic multipliers) developed here will be called "conditional dynamic multipliers" with the "conditions" stated in each instance.

Dynamic Responses to Income Growth

A sensitivity study of the effect of a change in income was selected as the first sensitivity analysis to be performed. The income shock to be analyzed consists of a single period, one percent increase in per capita disposable income. This shock will be injected into the model in 1972 with all other exogenous initial conditions held constant at their 1971 level. Comparisons of the time-paths of endogenous values generated by the shock run will be made with time-paths of endogenous variables generated by a base run where all exogenous values are held at their 1971 levels.

The primary response expected from an income shock of this type is a rise in meat consumption and -- to a lesser extent -- a rise in food grain consumption. These increased demands would then set in motion a number of secondary impacts and dynamic responses, such as stimulating long-term livestock production, increased feed-grain demand, etc.

Figure VI.2 shows the base run and shock run time-paths of per capita meat consumption,[1] and a plot of the difference between these two time-paths. In the period of the income shock (period 0) no consumption response is possible because meat supplies are fixed. Meat prices rise causing subsequent production and consumption increases. The cyclical pattern observed for the per capita consumption of meat is due to meat production cycles. Since consumption equals production the cyclical pattern for production and consumption are identical.

The cyclical, dampening pattern of the difference plot for aggregate meat production and consumption is believed to be due to simulated overreactions of the producers to price increases generated by the temporary income shock. Producers first over produce and cause prices to fall. They then cut back in another over-reaction, but eventually after about two series of expansions and contractions, production returns to the base run pattern.

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[1]Meat is defined here as the sum of pork, fed beef, non-fed beef, turkey and chicken slaughter where pork, fed beef and non-fed beef are in liveweight units and turkey and chicken are in ready-to-cook units.

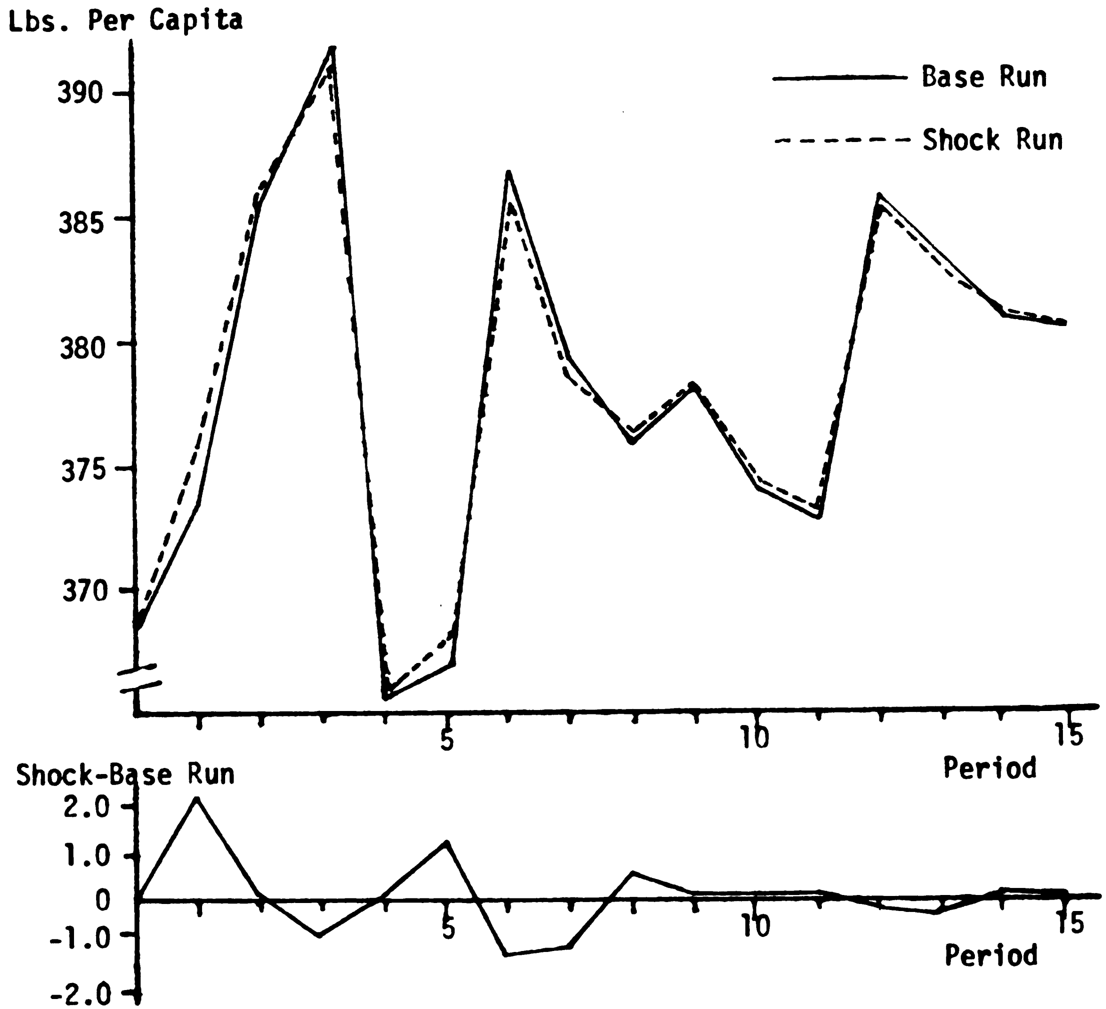

Figure VI.2. Per capita meat consumption response to a 1 percent income shock

Total response over a 15-year period to the single period one percent income shock is a net increase of 2.27 pounds of meat consumption per capita, i.e. the integral of the difference curve is a positive 2.27. In this case the 15-year net effect or net difference is larger than the first period difference of 2.08 pounds. This need not be the case with all long-run net responses since the cyclical patterns of positive and negative difference may tend in some cases to be more symmetric leading to a very small cumulative net effect. Conceptually the cumulative net effect could be zero while single period effects or differences were substantial.

Table VI.2 expresses, in percentage terms,[1] the differences between the base run and shock run for each of the first seven periods following the shock and the net cumulative effect.[2] The row representing "all meat" (consumed and produced) is the tabular representation of the difference plot in Figure VI.2. Since the values in Table VI.2 are in percentage terms and the size of the income shock was one percent, the figures in Table VI.2 can be interpreted as elasticities by moving the decimal point two points to the right.

A great deal of information is embodied in Table VI.2. Interpretation of the causal linkages embodied in the model leading to the figures in Table VI.2 is a complex task. While different interpretations could be developed, major points and causal relations being displayed in figures contained in Table VI.2 appear to be the following.

---

[1]The difference is expressed as a percent of the base run value for each respective period.

[2]Cumulative net percentage effect is formed by summing all intermediate period percentage difference effects.

Table VI.2 Estimated Effects of a One Percent Income "Shock"[d]

	Short-run[e] 0	Intermediate Periods[e] 1	2	3	4	5	6	7	Long-Run[e] 15 Period Net Cumulative Effect
Crops									
Prices									
Wheat	+.0000	+.0000	+.0000	+.0000	.+0000	+.0000	+.0000	+.0000	+.0000
Corn	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000
Soybeans	+.0090	-.0063	-.0013	+.0036	-.0009	+.0054	-.0057	+.0021	+.0021
Quantity (Produced)[c]									
Wheat	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000
Corn	+.0000	-.0004	+.0004	+.0001	-.0002	+.0001	-.0002	+.0001	-.0001
Soybeans	+.0000	+.0040	-.0004	-.0016	+.0007	+.0001	+.0035	-.0007	+.0052
Quantity (consumed)									
Wheat for Food	+.0045	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0005
Feedgrain Fed	+.0625	+.0031	-.0010	-.0001	+.0008	+.0037	-.0012	-.0008	+.0099
Protein Feed Fed	+.0001	+.0121	-.0024	-.0035	+.0017	+.0022	+.0042	-.0015	+.0126
Gross Crop Value[a]	+.0030	+.0000	-.0013	+.0016	-.0003	+.0021	-.0010	+.0003	+.0055
Livestock									
Prices									
Fed Beef	+.0333	-.0240	-.0105	-.0006	+.0040	-.0071	-.0093	+.0080	+.0040
Pork	+.0245	-.0333	+.0032	+.0232	-.0005	-.0197	+.0167	+.0212	+.0178
Milk	+.0507	+.0249	+.0235	+.0109	-.0063	-.0023	+.0004	+.0008	+.0106
Chicken	+.1029	-.0649	+.0107	-.0020	+.0111	-.0165	+.0185	-.0039	+.0243
Quantity (Produced & Consumed)[c]									
Fed Beef	+.0000	+.0051	+.0023	-.0004	-.0025	+.0016	-.0008	+.0017	+.0085
Pork	+.0000	+.0063	-.0024	-.0057	+.0034	+.0082	-.0035	-.0054	+.0013
Milk	+.0000	-.0006	-.0002	+.0008	+.0015	+.0020	+.0009	+.0000	+.0036
Chicken	+.000	+.0060	-.0028	+.0005	-.0078	+.0015	-.0028	+.0020	+.0030
All meat	+.0000	+.0056	+.0004	-.0014	+.0002	+.0033	-.0023	-.0023	+.0065
Gross Livestock Value[bc]	+.0000	+.0269	-.0151	-.0027	+.0027	+.0025	-.0052	+.0063	+.0174
Government Reserves									
Food Grain	-.0012	-.0022	-.0027	-.0020	-.0021	-.0024	-.0025	-.0020	-.0020
Feed Grain	-.0191	-.0244	-.0150	-.0109	-.0128	-.0182	-.0139	-.0090	.0112

[a]Gross value includes revenue from wheat, soybeans, corn, oats, barley, sorghum and cotton.

[b]Gross value includes revenues from pork, fed beef, non-fed beef, milk, chicken, turkey and eggs.

[c]No response occurs for these categories during the shock by definition of recursive model.

[d]The income shock consists of a one percent increase in income for one period only followed by a return to the previous income level.

[e]Short-run, intermediate and long-term multipliers are expressed in percentage terms, i.e. the difference between the shock and base run as a percent of the base run value.

The initial period responses include price rises for all meats and soybeans, but there is a marked absence of any price response for wheat and corn. This is a result of the initial conditions specified. These conditions cause excess capacity to be simulated for feedgrain and foodgrain production; thus the simulation includes government purchase of stocks to maintain wheat and feedgrain prices. Because of this any upward price pressure on wheat and feedgrains is offset by reduced government demand. It is observed that government stock levels of food grains and feedgrains decline below the base run by .0012 and .0191 percent respectively in the period of shock.

The recursive nature of the crop and livestock supply models preclude any supply response during the period of the shock. Increased feedgrain and protein feed demand occurs during the period of the shock since all demands are simultaneous in nature. An increase in feed consumption without an increase in livestock production may appear irrational but is realistic since more animals are started on feed in the period of the shock but are not slaughtered until the next period.

The magnitude of responses in the period of the shock are contingent on the size of the income elasticities in the various equations and the initial conditions of the model. Note that the income elasticities indicated are not necessarily similar to those reported in Chapter IV. The income elasticities reported in Chapter IV were mean value single equation *ceteris paribus* income elasticities. These elasticities are determined away from the mean and in a multiple equation simultaneous solution procedure.

With regard to the secondary impacts on feed demand in the period of the shock and subsequent periods, several observations are warranted. As previously alluded to, government stocks initially prevent corn prices from rising as feed demand increases. However soybean prices do rise until subsequent positive production response lowers them. Hence in the shock period soybean prices rise and corn prices do not. As a result some substitution of feedgrain for protein feed occurs in the simulation. Feedgrain utilization rises by .0625 percent while high protein feed rises by only .0001 percent in period 0. If the two feeds were perfect complements in all cases the two percentage changes would have been identifical. In the first period after the shock we observe that soybean prices are below the base run by .0063 percent. This is believed to be due to an increase in soybean production above the base run level by .004 percent. The lower soybean prices and thus lower protein feed prices in this period lead to heavier use of protein feeds relative to feedgrains. Protein feed use increases to .0121 percent above the base run while feedgrain use is only .0031 percent above the base run. The analysis of feedgrain-protein feed substitution in response to the corn-soybean price ratios cannot be carried many periods beyond the initial shock period, since many other factors begin to enter the determination of the quantity of feed use, e.g. livestock herd composition.

The long-run cumulative effects of the income shock on livestock prices, quantities produced and consumed, and associated changes in feed demand are even more difficult to associate with causal flows than the short-run effects just discussed. Over a 15-

year period, cumulative net increases in consumption (and production) of livestock products is greatest for beef followed by milk, chicken and pork. The position of beef in this array is as expected, but the position of milk and pork are perhaps unexpected until one considers that these long-run response are more conditioned by production response over time than the income elasticities. Demand increases definitely effect production response through the generation of higher livestock prices, but resistance to increased production due to input supplies also shapes the production response. With regard to input supplies, feedgrains were in ample supply at a steady price due to over-production tendencies and government stocks. Some price response is caused by increased protein feed demand. A cyclical protein feed cost pattern is observed as demand and supply interact to "cob-web" to an equilibrium or in this case return to the base run level. The simulated soybean price rises may over time act to place protein intensive livestock categories at a disadvantage relative to roughage and grain intensive livestock categories with regard to efforts to expand production. Indeed a rationale of this type would appear to assist in explaining the relatively larger growth in production and consumption of fed beef and dairy (two grain-roughage intensive livestock categories) versus pork and chicken (which tend to be relatively heavy users of protein feeds).

In contrast to the long and rather complex set of interactions occurring in the markets for livestock products and protein feeds, the more highly controlled foodgrain or wheat market and feedgrain market are simulated to have rather short and uninvolved responses.

Specifically the income shock generates a single period increase in human consumption of wheat. This does not affect wheat price since the government could totally offset the increase in demand by decreasing stock. Government foodgrain stocks drop below the base run by .0012 percent in the shock period. Since wheat prices are unaffected by the income shock and policy prices are constant, wheat production is virtually[1] unaffected.

With regard to gross crop and livestock revenue it is observed that both revenue categories are increased initially over a 15-year period. Gross revenues from livestock over the long-run increase in percentage terms about three times as much as crop gross revenues. The change in crop revenue is primarily derived from increased soybean production and price levels. Gross revenue increases for all livestock but beef and dairy provide the majority of income growth in absolute terms.

In summary, the simulated response to a single period income shock is as follows;

1. Meat consumption-production and prices rise in both the short-run (one period response) and long-run (15-year net cumulative response).
2. Rising livestock production increases demand for feedgrains and protein feeds by .0625 and .0001 percent respectively in the short-run and by .0099 and .0126

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[1] The term "virtually" unaffected is used with regard to wheat production response because some effects filter through the feedgrain-protein feed market interaction to the supply activity for wheat. However these effects are insignificant to the fourth decimal point in terms of percentage differences between the base and shock run.

percent respectively in the long-run. This implies an indirect dynamic long-run income elasticity of demand for feedgrains of .99 and for protein feeds of 1.26.

3. Domestic foodgrain and feedgrain policies create stable feedgrain supplies, foodgrain supplies and foodgrain demand. That fact that government policies cause feedgrain prices to remain steady despite increased demand for feed tends to encourage expanded meat production in response to demand generated by the income shock.
4. Gross revenue increases are generated for both crops and livestock. The implies long-run income elasticities of gross revenue for crops and livestock are .55 and 1.74 respectively.

Lastly it is believed that the short-run, intermediate and long-run responses arising from the simulation are quite reasonable and consistent with previously observed responses and concepts of expected response. Hence the income shock analysis reveals no major need for revision of the model.

Dynamic Responses to Devaluation

A second shock analyzed is the dynamic response to a single period 10 percent devaluation of the United States dollar. This shock lowers the real export price of wheat, feedgrains and soybeans. Hence an increase in export demand for these commodities is expected, which in turn creates subsequent upward pressure upon domestic crop prices. This shock will test the validity of the export sector price linkage mechanism as well as test the domestic model's reaction to a simulated increase in grain export demand.

Policy implications of the 10 percent devaluation may be of particular significance since 1971 initial values are used. In 1972 the United States devalued the dollar by approximately eight percent. The initial conditions used in the analysis conducted here meet the criteria of being as reflective as possible of the conditions existing when the devaluation policy decision was made. The elasticities of response derived from the dynamic multipliers should therefore be good estimates of the actual elasticities of response occurring in 1972. Scenarios of exogenous variables reflective of events after 1972 will not be provided. The base run will consist of a steady state run given the 1971 conditions as initial conditions.

Figure VI.3 presents plots of the differences between endogenous values simulated for soybean, feedgrain and wheat exports in the base run versus the shock run. The simulated devaluation causes an increase in all three forms of export during the shock period. The greatest response is for soybean exports. The short-run elasticity of response is estimated to be .515, for soybean exports. (See Table VI.3 for other conditional multipliers expressed in percentage terms. Elasticities can be derived from the conditional percentage term multipliers by shifting the decimal point one place to the right.)

Simulated export response in subsequent periods is quite different for each of the three categories of exports. The differences can be attributed largely to simulated government production control and stock policies. Government food grain policies prevent any wheat price or production responses; hence after the devaluation shock is

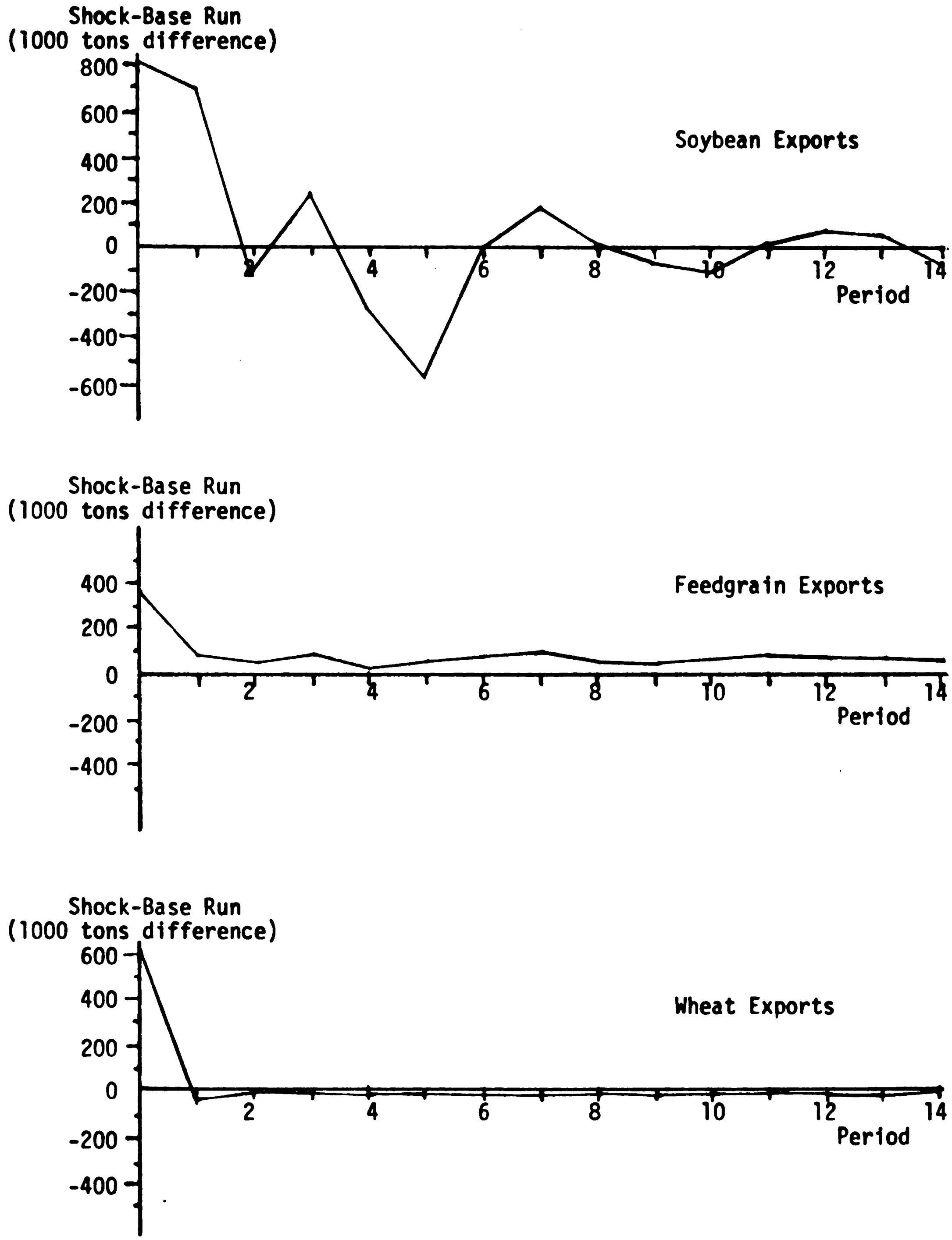

Figure VI.3. Wheat, feedgrain and soybean export response to a 10 percent devaluation shock removed, wheat prices are the same as for the base run. A reduction in government wheat stocks during the shock period prevented wheat prices from rising in reaction to the devaluation. Government stocks fall below the base run levels in subsequent periods of the shock run. Since estimated wheat exports are a positive function of total U.S. stock, and government stock levels are down relative to the base run, wheat exports with devaluation are simulated to be slightly less than wheat exports in comparable periods of the base run.

Simulated soybean exports follow a dampening oscillatory pattern. As was the case with the income shock, soybeans exhibit larger and longer dynamic responses than either foodgrains or feedgrains. The reason for the sensitivity of the soybean market is the lack of any stocks or surplus capacity in the soybean market.

Domestic soybean prices rise in the period of the shock thus offsetting the effect of devaluation. Soybean production then rises in the period after the shock in response to higher soybean prices. This causes soybean prices to drop in the first period after the shock and stimulates increased exports.

Interactions between soybeans and feedgrains in the devaluation shock are similar to those with the income shock. Specifically, corn prices are held "nearly"[1] constant due to government support

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[1]The term "nearly" is used because the iterative adjustment process which alters government stock demand to maintain a support price does so only within a given range of error. Since corn and soybean prices are determined simultaneously a response in corn price occurs in the simultaneous solution process after the last stock adjustment occurs. This response is beyond the control of the adjustment process. The iterative adjustment process therefore is only capable of maintaining

(footnote continued)

actions, but soybean prices oscillate as the market adjusts to the devaluation. (Soybean price oscillations net out to a zero change from the base run over 15 periods.) During the first several periods after the shock, whenever soybean prices are above the base run level feedgrains are substituted for protein feeds relative to the base run ration.

Another interaction between corn and soybeans involves fluctuation in production of soybeans. As soybean acres are shifted in and out of production in reaction to price changes some disturbance to corn acreage is observed. Corn acreage or production is generally down slightly when soybean production is up and vice versa. Oscillating corn production, however, does not affect corn price since they are held at the support level by government actions.

Estimated differences in feedgrain exports for the base run and shock run as shown in Figure VI.3 were unexpected, both from the point of view of perceived model structure and real world observation. The rise in feedgrain exports in the period of the shock is logical and consistent with perceived model structure, i.e. devaluation reduces export price which results in an increase in feedgrain exports. The continued positive difference value for feedgrain exports in subsequent periods is puzzling. Other endogenous variables modeled to affect feedgrain exports include feedgrain production, feedgrain stock and domestic corn price. Feedgrain stock levels are estimated

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1 (continued)
support price within about a one percent tolerance range. This may be the cause of illogical dynamic model behavior to be presently discussed. The same problem occurs in the wheat stock model in attempting to maintain wheat support prices but is less serious due to lower price elasticities and a simpler set of demand interlinkages.

to be down relative to the base run while feedgrain production levels are oscillating above and below the base run. Corn prices are held nearly at the same support price as in the base run, but due to some error in the iterative adjustment process required to do this, corn prices also randomly oscillate slightly above and below the base run. The model is specified such that increased feedgrain production, increased stock holdings or lower domestic prices will lead to larger feedgrain exports. Since feedgrain stocks are consistently lower in the stock run than in the base run, and corn production and price are somewhat randomly above and below the base run, it was expected that feedgrain export simulations should have dropped to a level slightly below the base run in periods following the shock with perhaps an occasional oscillation reaching above the base run level. The pattern of feedgrain export response therefore appears reasonable but the precise magnitude of the subsequent decline is to be questioned and warrants further investigation.

Secondary dynamic impacts are simulated to carry into the livestock supply activities. Disturbances in soybean price and production spread into feedgrain supply and livestock supply. Meat production is reduced relative to the base run level. Unexpected increases occur in pork, milk and chicken production in the first period after the shock. These reactions may be due to the erroneously simulated drop in corn prices caused by imprecise maintenance of the corn support price. Irrespective of the causes the simulated secondary responses in the livestock sector appear to indicate relatively small secondary dynamic responses in reaction to the devaluation.

Table VI.3 Estimated Effects of a 10 Percent Devaluation "Shock"[d]

	Short-run Impact	Intermediate-Period Multipliers							Long-run Multiplier
	0	1	2	3	4	5	6	7	15 $\sum_{i=1} M_i$
Crops									
Prices									
Wheat	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000
Corn	-.0034	-.0002	+.0004	-.0005	-.0009	.0003	.0001	.0002	-.0103
Soybeans	+.1070	-.1080	+.0149	-.0336	+.0345	+.0086	+.0008	-.0264	-.0000
Quantity (Produced)[c]									
Wheat	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000
Corn	+.0000	-.0071	+.0055	-.0008	+.0017	-.0016	-.0007	+.0000	+.0006
Soybeans	+.0000	+.0543	-.0091	+.0003	-.0151	+.0060	+.0086	+.0064	+.0487
Quantity (Consumed)									
Wheat for food	+.0000	+.000	+.000	+.0000	+.0000	+.0000	+.0000	+.0000	+.0000
Feedgrain Fed	.0360	-.0060	+.0040	-.0078	+.0042	+.0123	-.0018	-.0128	+.0307
Protein feed fed	-.0699	+.0650	-.0093	-.0036	-.0231	+.0178	+.0195	+.0049	+.0000
Gross Crop Value[a]	.0106	-.0200	+.0067	-.0114	+.0109	+.0048	+.0029	-.0063	+.0178
Livestock[c]									
Prices									
Fed Beef	+.0000	+.0250	-.0311	-.0292	+.0289	+.0210	+.0081	-.0030	-.0002
Pork	+.0000	+.0178	-.0235	+.0426	+.0080	-.0888	+.0242	+.1042	-.0489
Milk	+.0000	+.0000	-.0033	+.0010	-.0007	-.0051	+.0004	+.0049	-.0011
Chicken	+.0000	+.1004	-.1640	+.0307	-.0035	+.0407	-.0118	-.0130	-.0236
Quantity (Produced and Consumed)									
Fed Beef	.0000	-.0074	+.0067	+.0082	-.0058	-.0067	-.0014	+.0033	+.0008
Pork	.0000	+.0051	-.0050	-.0178	+.0030	+.0536	-.0117	-.0341	+.0017
Milk	.0000	+.0014	+.0016	+.0019	+.0029	+.0021	-.0001	-.0030	-.0066
Chicken	.0000	+.0051	+.0022	-.0106	+.0057	-.0049	+.0020	-.0005	+.0213
All Meat	.0000	-.0040	+.0054	-.0024	-.0018	+.0099	-.0039	.0089	-.0059
Gross Livestock Value[b]	.0000	+.0165	-.0211	-.0039	+.0117	+.0001	-.0002	-.0016	-.0132
Government Grain Reserves									
Foodgrain	-.0228	-.0062	-.0048	-.0046	-.0043	-.0088	-.0094	-.0071	-.1151
Feedgrain	-.2472	-.1474	-.0827	-.0609	-.0729	-.0968	-.0749	-.0380	-1.0951
Exports									
Wheat	+.0272	-.0004	-.0001	-.0001	-.0001	-.0001	-.0001	-.0001	+.0236
Feedgrains	+.0162	+.0045	+.0028	+.0044	+.0018	+.0030	+.0043	+.0048	+.0031
Soybeans	+.0515	+.0425	-.0077	+.0154	+.0174	-.0364	-.0003	+.0115	+.0554

[a]Gross value includes revenue from wheat, soybeans, corn, oats, barley, sorghum and cotton.

[b]Gross value includes revenue from pork, fed beef, non-fed beef, milk, chicken, turkey and eggs.

[c]No response occurs for those categories during the shock period by definition of a recursive model.

[d]The devaluation shock consists of a one period 10 percent devaluation, followed by a return to the previous exchange rate.

[e]Short-run, intermediate and long-term multipliers are expressed in percentage terms, i.e. the difference between the shock and base run as a percent of the base run value.

Devaluation causes gross revenue from crops to increase while livestock gross revenue falls over a 15-year period relative to the base run. The long-run elasticity of response for gross revenue from crops is estimated to be relatively low at .178. The long-run elasticity of response for gross revenue from livestock is also low and negative at a value of -.132.

In summary a 10 percent single period devaluation shock produces the following major responses:

1. A significant increase in soybean exports occurs for two periods. The elasticity of response in the initial period is .515. Wheat and feedgrain exports increase but to a lesser degree in the shock period with elasticities of .272 and .162 respectively. Following the shock period, feedgrain and wheat exports return to approximately the base level while soybean exports continue to oscillate relative to base run.
2. Government holding of stocks is reduced to offset the increase in demand for grains caused by the devaluation. This effectively stabilizes wheat and corn prices while soybean prices oscillate significantly around base run levels.
3. Feedgrain and protein feed substitution occurs in livestock feeding in reaction to oscillating soybean prices.
4. Impacts of a devaluation in the livestock sector appear to be minimal. However a decline in meat production as well as livestock prices is simulated over a 15-year period, and livestock gross revenue falls.

The analysis of a devaluation shock has raised some questions about simulated model results which have not been resolved, specifically the simulated feedgrain export response. The problem of inaccuracy in maintaining support prices should be noted, but does not appear serious. In reality the government does not have the ability to precisely maintain support prices either.

Perhaps the major policy implications to be drawn from this evaluation is that in the presence of reserve stocks, any increase in demand for grains that does not exceed stock holdings has little impact other than to alter stock levels. If stocks do not exist, as in the case of soybeans, an exogenous shock to demand can create significant and rather long lasting price instability according to the model's estimated dynamic response pattern.

Dynamic Responses to Grain Export Shocks

The last shock case to be analyzed deals with the set of responses simulated for grain export shocks. In this analysis multiple shocks will actually be imposed in that wheat, feedgrain and soybean export levels will all be changed at once.

The first case considered injects changes in export quantities comparable to the actual 1972 increases, or approximately 16, 16 and 9 million tons respectively, for feedgrains, wheat and soybeans. Soybean exports are measured in meal equivalents. The base to which this shock run is compared will be a steady state run using as initial conditions the 1971 exogenous value set. Dynamic responses in this analysis will be reported in actual differences between the base run and shock run as opposed to percentage differences which were reported for the income and devaluation shocks.

A second export shock analysis will consist of injecting an export shock of a comparable nature to the Soviet Union purchase of grain in 1972. This shock effect will be compared to the effect of the 1972 grain export shock. Lastly, several alternative grain export changes of various sizes will be analyzed assuming various levels of government reserves.

This analysis of grain export shocks will further validate the model and in addition provide some policy information regarding the following three questions:

1. To what extent have increased grain exports affected the U.S. agricultural sector?
2. What portion of the total 1972 shock can be attributed to the Soviet Union's grain purchases?
3. What effect did U.S. government grain reserve stock policies have on dampening the impact of the 1972 export shock and how might this effect have differed had the government held different levels of grain stocks?

The Simulated Dynamic Impact of 1972 Export Changes

Crop Sector Response: The model indicates that upward pressure was exerted on wheat, feedgrain and soybean prices in the period of the export shocks. The estimated initial period effect of the increased grain and soybean exports in 1972 was to increase wheat prices by 44.6 cents, corn prices by 6.7 cents and soybean prices by 149 cents

(Table VI.4). By way of comparison, recall that according to the model predictions in Chapter V, Table V.4, Page 111, which were based on all exogenous changes that occurred in 1972, price increases for wheat, corn and soybeans were 38, 26, and 115 cents respectively. Hence, the export shock of 1972 accounted for nearly all of the price change in wheat during 1972. Likewise, the simulation indicates that increases in exports accounted for the majority of the soybean price change. On the other hand, increased feed grain export is estimated to have accounted for only about one-fourth of the predicted rise in 1972 feedgrain prices.

Several responses can be observed in the model which help "cushion" the export shock. Conditions in the model led to excess corn and wheat production in the simulated 1972 crop year.[1] This excess production was used to fill part of the increased export demand. If historical stock liquidation responses were to have been followed in this situation, the simulation run indicates that the government would have liquidated 10.2 million tons of wheat and its entire estimated feedgrain stock (i.e. 6.1 million tons) in an effort to cushion the effect of the export shock upon crop prices.[2]

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[1]This is reflected in the model by the fact that the base run simulation required the government to purchase 1.1 and 6.7 million tons of feedgrain and wheat respectively, in the simulated 1971 crop year to maintain corn and wheat support prices. It should be recalled in this regard, that in the 1971 crop year the crop and livestock sectors were recovering from the 1970 corn blight. Favorable crop production incentives were being offered by the government in 1971 to speed recovery, which, according to the model were generating excess capacity in the form of corn and wheat stock accumulations.

[2]In the base run where no export shock occurred the government is simulated to have had to purchase 5.7 and 19.1 million tons of wheat

(footnote continued)

The effects of the simulated 1972 export shock extend beyond the shock period in several ways. Corn and wheat prices in both the base run and shock run decline to support price levels in the first period after the shock, thus the difference in these prices between the two runs is zero after the shock period. Different stock purchases are required in the shock run as compared to the base run to maintain these support prices for corn and wheat. Over a 15-year period the model estimates that in any given year the government's typical stock position for the shock run would have been approximately 5.6 million tons (-84.057/15) below the base run level for foodgrain stocks and approximately 11.4 million tons (-171.348/15) below the base run for feedgrains.

Since the upward price pressures are stronger for wheat and soybeans than for corn, some adjustments in the crop sector occur to alleviate this imbalance in subsequent periods. Specifically, during the 15 simulated periods following the shock, the model predicts corn production will fall a cumulative total of 3.45 billion bushels or an average of approximately four percent per year below the base run; while on the average wheat and soybean production rise 1.1 percent and 2.0 percent per year, respectively, above the base run values.

The model indicates that no excess capacity existed for soybeans nor did the U.S. government hold soybean stocks with which to cushion the 1972 shock; hence, the initial price response for soybeans

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2 (continued)
and feedgrains, respectively, to maintain support prices. In table 2 a total difference in period 0 between the base run and shock run of 15.0 = 10.2 + 5.7 and 25.2 = 6.1 + 19.1 for government foodgrain stocks (wheat) and feedgrain stocks, respectively, is indicated.

was estimated to be relatively large (Table VI.4). Predicted soybean price decreases in subsequent periods are attributed to a simulated over-reaction of producers in the initial period. Under the simulated shock run, government purchases would have been required to maintain the soybean support prices in the second period after the shock. After soybean prices drop below the base run level for the first few periods of the shock run, they begin to rise and converge at the base run level. Hence, the 15-year cumulative effect of 37.4 cents is less than the estimated difference in the initial period.

Livestock Sector Response: The simulated crop sector responses indicate that corn and wheat prices are quickly stabilized by government action and excess capacity. However, soybean prices are simulated to be extremely volatile because of a lack of stock holdings and excess capacity (Table IV.4). The initial sharp increase in soybean prices coupled with an associated fall in corn production results in a simulated decline in livestock production during the 15-year period following the export shock. In particular, the simulated increase in soybean prices causes protein intensive livestock production to fall. Over the 15-year period pork and chicken production falls by a cumulative total of 1.33 and .37 percent respectively, and beef and milk production declines by 0.06 and 0.08 percent respectively below the base run cumulative levels.

While the simulated 15-year cumulative reductions in livestock production appear relatively small, intermediate single period impacts are quite significant. For example, during the first, second, and third periods following the shock, differences between the base

Table VI.4 Estimated Effects of the 1972 Grain Export Increase on Selected Endogenous Variables

	Estimated 1971 Level	Current and Intermediate Effects 0	1	2	3	4	Cumulative Long Run Effect
Crops							
Prices:							
Wheat ($/bu.)	1.06	.446	.000	.000	.000	.000	.446
Corn ($/bu.)	.85	.067	.000	.000	.000	.000	.067
Soybean ($/bu.)	2.45	1.490	- .342	- .647	- .264	.075	.374
Quantity[c]							
Wheat (bil. bu.)	1.619	.0	.231	.0	- .012	.0	.271
Corn (bil. bu.)	5.699	.0	- .476	.058	.104	.292	- 3.450
Soybean (bil. bu.)	1.204	.0	.363	.177	- .580	- .115	.357
Gross Crop Value[a] (Bil. $)	11.673	3.143	- .146	- .432	- .207	.357	2.047
Livestock							
Prices:[c]							
Fed Beef ($/cwt.)	28.74	0	5.960	- 1.270	- .786	.980	1.010
Pork ($/cwt.)	20.91	0	4.330	- .710	1.740	5.210	8.760
Milk ($/cwt.)	5.07	0	.082	- .038	.038	.118	.123
Chicken ($/cwt.)	11.48	0	8.907	- 5.244	-4.891	2.569	.871
Quantity[c]							
Fed Beef (bil. lbs.)	30.614	0	- 3.051	.234	3.762	- .207	- .311
Pork (bil. lbs.)	20.404	0	.407	- .227	-3.556	-2.335	- 4.196
Milk (bil. lbs.)	119.539	0	- .399	- 1.547	-1.976	- .414	- 1.574
Chicken (bil. lbs.)	8.504	0	- 1.024	.674	.250	- .225	- .455
Gross Livestock Value[b] (Bil. $)	23.283	0	3.491	- 1.214	-3.588	1.478	- 2.061
Government Reserves							
Food Grain (mil. tons)	23.417	-15.925	-10.665	- 8.531	-8.006	-7.112	- 84.057
Feed Grains (mil. tons)	2.225	-25.238	-36.353	-21.673	-3.069	.141	-171.348

[a]Gross value includes gross revenues from wheat, corn, soybeans, corn, oats, barley, sorghum and cotton.

[b]Gross value includes gross revenues from pork, fed beef, non-fed beef, milk, chicken, turkey and eggs.

[c]No response occurs for these categories during the first period by definition of the recursive model.

Note: All prices and gross values are in 1971 dollars.

and shock runs ranged from .33 percent for milk in period one to 15.5 percent in the third period for pork, with the typical difference being about five percent.

It is interesting to note that during the third and fourth periods after the shock, which hypothetically compare to the crop years 1975 and 1976, substantial dynamic responses for the simulated 1972 export shock still remain -- particularly in the livestock sector. In fact, these dynamic residual effects are estimated to be larger for beef, pork and milk quantities in the third period after the shock than in the first period.[1] General observation of model output indicates that most of the simulated livestock responses occur within four to seven years, or roughly one cycle, but frequently some adjustments carry in to the next cycle.

Gross Value of Crops and Livestock: The gross value of crop production in the shock run rises over the base run during the period of the shock by $3.143 billion. This increase is due solely to increased crop prices. In subsequent periods the gross revenue of the crop sector drops below the base run due to falling prices and reduced crop production. Hence the cumulative simulated net difference between the two runs for crop sector gross income is only $2.047 billion.

Gross revenue from livestock is not influenced in the shock period due to the recursive specification of livestock supply response. In the first period after the export shock the simulated response in

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[1]The positive sign on pork quantity in period one is due to an immediate simulated reaction in which breeding stock is liquidated as the first response to unfavorable economic conditions. This liquidation tempoarily raises pork production.

the livestock sector generates (in comparison to the base run) relatively greater price increases than production declines. Gross revenue is thus higher than in the base run. Over a longer period however, the relatively higher long-run elasticities of livestock supply response to increased input cost, cause relatively greater declines in quantity than increases in price (the opposite case of the single period effect). Hence, the cumulative gross income from livestock is $2.061 billion below the base run.

The 1972 Soviet Union Purchase: A simulation run was made which injected an export shock into the system equivalent to the 1972 Soviet Union grain purchases (9.5 and 4.5 million tons of wheat and feedgrains respectively). Although the injection of these purchase levels into the model represent a significant proportion of the total 1972 export shock, they do not create any large deviations from base run values.

Specifically, the shock from the Soviet Union purchase generates no deviation from the base run for corn prices (excess capacity and government stocks fully offset the shock). Wheat prices deviate from the base run by 16 cents for one period (as compared to 44.6 cents under the full shock). Soybean prices in this case are simulated to rise over the base run by no more than six cents (as compared to a maximum of 149 cents under the full shock). Since soybean prices change very little and corn price none at all relative to the base run, the simulated deviations from the base run are very small in the livestock sector.

The marked absence of a large simulated response to the shock represented by Soviet grain purchases is interpreted to be due in part, to the following: (1) the lack of any soybean export shock; (2) the existence of simulated excess capacity for corn and wheat, and (3) government stock liquidations.

Stability and the Level of Grain Reserve Stocks

The simulated effects of three different levels of increased grain exports given three alternative government grain reserve scenarios also were examined. The three levels of grain export shocks (in millions of tons) are (1) level A: 16.0 food grain, 16.0 feed grain, 9.0 soybeans; (2) level B: 6.0 food grain, 6.0 feed grain, 4.5 soybeans; (3) level C: 2.0 food grain, 2.0 feed grain, 1.0 soybeans.

Since the magnitude of simulated export effects are conditioned by the size of the government grain reserves at the time of the export shock, reserve stock levels (in millions of tons) for food grains and feedgrains of 20.0 food grain and 6.0 feedgrain (high), 10.0 wheat and 3.0 feedgrain (medium) and 0.0 food grain and feedgrain (low) respectively, are programmed into the model and examined. These three levels would appear to cover the range of feasible reserve stock levels. Using the identical analytical procedure employed above, consideration is now given to how the dynamic responses would have differed had different levels of export purchases and reserve stocks existed.[1] The conditional dynamic response to various

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[1]The level A export level coupled with high government reserve grain stock is the 1972 export shock case, i.e., the first two columns of short and long-run effects in table 3 can be derived from Table VI.4.

combinations of reserves and exports are presented in Table VI.5.

As grain reserves become smaller, the sensitivity of the agricultural sector to a given export "shock" becomes increasingly more pronounced. For example, if the low (instead of high) reserve stock level had existed when the 1972 export change was simulated, the model estimates the price of wheat would have more than quadrupled in the short run while the prices of corn and soybeans would have advanced by 18 and 62 percent respectively, over the base run values. Accordingly, the quantities of wheat and soybeans produced in the period after the shock are simulated to increase by 127 and 18 percent, respectively, while the quantity of corn produced would have been reduced by 40 percent due to strong competition from wheat and soybeans for land.[1] The increases in livestock prices with simulated low government stocks, vis-a-vis those occurring with high stocks, are relatively the same in the short-run but in the long-run the effects are substantially different, with considerably larger increases when reserve stocks are low.

For the "typical" or "most likely" export level, the simulated effects are identical for both medium and high "shock" levels. Only when reserve stock levels are extremely low are severe stability problems predicted. On the other hand, when very small increases in exports are simulated, the effects are identical regardless of the level of government reserve stocks.

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[1]Because the U.S. government has not generally held soybean stocks high, medium and low stock positions are not considered for soybeans, but only for feedgrains and wheat. Hence soybean supply and demand responses are not greatly affected by the stock positions scenarioed.

Table VI.5 Estimated Effects of Three Increased Levels of Grain Exports Under Three Alternative Government Stock Levels

		A (Large)						B (Typical)				C (Small)		
		Government Reserve Stock Level												
	1971	High		Medium		Low		High Medium		Low		High Medium Low		
	(est.) level	S-R	L-R	S-R	L-R	S-R	L-R	S-R	L-R	S-R	L-R	S-R	L-R	
Crops														
Prices:														
Wheat ($/bu.)	1.06	.446	.446	.518	.518	3.266	3.266	.052	.052	.159	.159	.014	.014	
Corn ($/bu.)	.85	.067	.067	.112	.112	.156	1.094	.0	.0	.0	.0	.0	.0	
Soybean ($/bu.)	2.45	1.490	.374	1.490	.371	1.470	.559	.715	.149	.714	.170	.160	.044	
Quantity[c]														
Wheat (bil. bu.)	1.619	.231	.271	.254	.299	2.049	18.044	.020	.034	.099	.083	.241	.012	
Corn (bil. bu.)	5.699	- .476	- 3.450	- .512	- 3.817	- 2.253	- 20.496	- .127	- .052	- .203	- .011	- .385	- .016	
Soybean (bil. bu.)	1.204	.363	.357	.360	.347	.216	.097	.183	.173	.177	.174	.407	.035	
Gross Crop Value[a] (Billion $)	11.673	3.143	2.047	3.572	14.015	8.467	10.791	1.156	.526	1.077	.664	.177	.063	
Livestock														
Prices:[c]														
Fed Beef ($/cwt.)	28.74	5.960	1.010	6.600	1.200	5.990	9.700	2.760	- 7.800	2.150	.030	- .030	.0	
Pork ($/cwt.)	20.91	4.330	8.760	4.780	9.200	5.190	18.830	1.960	10.710	1.980	3.340	.000	.230	
Milk ($/cwt.)	5.07	.082	.123	.093	.153	.088	1.100	.033	.027	.011	.020	- .005	- .010	
Chicken ($/cwt.)	11.48	8.907	.871	9.398	.955	9.784	4.952	4.153	.275	3.739	.360	.455	.080	
Quantity[c]														
Fed Beef (bil. lbs.)	30.614	- 3.051	- .311	- 3.328	- .362	- 3.572	- 2.626	1.393	.066	- 1.160	- .017	- .044	.986	
Pork (bil. lbs.)	20.404	.407	- 4.196	.377	- 4.383	.341	- 7.716	.204	- 1.758	.229	- 1.635	.075	- .073	
Milk (bil. lbs.)	119.539	- .399	- 1.574	- .663	- 2.797	- .925	- 42.871	- .123	- .198	.095	- .150	- .227	.343	
Chicken (bil. lbs.)	8.504	- 1.024	- .455	- 1.030	- .439	- 1.024	- .166	- .489	- .402	- .483	- .403	- .102	- .331	
Gross Livestock Value[b] (Billion $)	23.283	3.491	- 2.061	3.742	- 2.108	3.695	- .882	1.675	- .122	1.374	- 9.899	.001	.131	
Government Reserves														
Food Grain (mil. tons)	23.417	-15.925	- 84.057	-15.663	- 73.440	- 5.970	+407.235	6.542	- 56.987	- 5.670	- 34.685	-1.967	-17.051	
Feed Grains (mil. tons)	2.225	-25.238	-171.348	-22.608	-142.503	-19.642	-237.441	1.395	-124.996	-13.687	-163.886	-5.770	-53.110	

[a] Gross value includes gross revenues from wheat, corn, soybeans, corn, oats, barley, sorghum and cotton.

[b] Gross value includes gross revenues from pork, fed beef, non-fed beef, milk, chicken, turkey and eggs.

[c] Short-run is defined as two years for these categories as opposed to one year for other categories. No response occurs in the first period for these categories.

Note: All prices and gross values are in 1971 dollars.

Finally, in the long-run the simulated gross revenue to crop producers is increased for all export levels while the gross revenue predicted for livestock producers is reduced.

Summary and Conclusion

The preceding grain export shock analyses have for the most part served to positively validate the model. In general response is appropriate under alternative specifications of conditions proxied by the model. Some of the conditions imposed were outside of the model's historical range of observation. Thus the model's ability to properly simulate responses to such conditions depends upon the validity of extrapolating a number of linear relations.

The following points emerged in answer to the policy questions enumerated at the beginning of this analysis. First, the model indicates that grain export shocks of the size of the 1972 increases cause considerable dynamic impact within the U.S. agricultural sector. The impacts are both large and long lasting in some cases. The Soviet Union's purchases of grain in 1972 however were found to provide only a partial explanation of the dramatic increases in U.S. agricultural prices during 1972. The limited effect of the Soviet grain purchases can perhaps be attributed to the lack of any soybeans in their purchases and to U.S. government reserve stock policies. Also the model does not consider psychological impacts associated with the purchases that may have spurred speculative actions.

The level of government grain reserve stocks was found to be extremely important in providing stability in the agricultural sector.

For instance, "low" grain stocks coupled with "high" increases in exports necessitate extraordinary short and long-run adjustments within the agricultural environment. The predicted dynamic adjustment processes are particularly long in the livestock and soybean markets.

Observations of the simulation results indicate important stability implications of past food grain and feedgrain stocks and provide tacit support for government holding of soybean stocks as well as food and feedgrain stocks. It would appear that a substantial dampening of price and quantity fluctuations due to an export shock could be obtained through soybean reserves.

CHAPTER VII

SUMMARY AND OUTLINE OF FUTURE MODELING POSSIBILITIES

This dissertation has dealt with and reported on the process and results of using a "systems approach" to analyze and "econometrically model" the "United States Agricultural Sector." The process began with a consideration of the feasibility and need for such a model and has now ended with specification of a working model. Further work upon the model by way of refinement, updating and expansion of the model's scope, still remain as possible future endeavors.

The objective established for building the model grew out of the desire to cope with and garner a greater understanding of the cause and future implications of recent unusual changes in United States agriculture. It was assumed that an econometric simulation model with a sector wide scope would be a useful analytical tool for achieving the understanding necessary to assess potential future changes in agricultural market conditions. Specifically the model is desired for the purpose of assisting in analyzing and projecting the intermediate to long-term effects of changing domestic and international market conditons on the grain, livestock and oilseed subsectors of United States agriculture.

The model presented in this dissertation is essentially an econometric model. In developing the model considerable use was made of the body of theory and testing procedures established in econometric literature. However the approach taken adopts the problem solving approach generally associated with the area of "systems modeling." Particular attention is given to the systems methodology related to "model identification," abstract model design, computerization and validation procedures.

Perhaps the most unique aspect of the model is its sector wide scope, including a consideration of domestic-international grain market interaction. The sector wide interrelations, flow of consequences, feedback loops and general dynamic properties of the agricultural sector are the key factors abstractly described and modeled in this effort.

The model as presently specified consists of three components:

1. Domestic Supply Component

   This component is capable of projecting the production of major commodities. The commodities can be grouped into two major subcomponents - livestock and crops.

   Livestock Commodities

   a) Fed beef (steer and heifer slaughter)
   b) Non-fed beef (cow slaughter)
   c) Pork (barrow, gilt and sow slaughter)
   d) Dairy (milk production - all grades)
   e) Chicken (broiler and other chicken slaughter)
   f) Eggs
   g) Turkey

Crop Commodities

a) Feedgrains (corn, barley, oats and sorghum)

b) Food grains (wheat)

c) Oilseeds (soybeans)

d) Cotton

2. Domestic Demand Component

This component consists of functions describing the various sources of domestic demand for the commodities listed in the domestic supply component. Demand for grain is generally broken into five sources, while demand for meat products is not subdivided. Grain demand sources include:

a) direct demand for human consumptions;

b) derived demand for use as livestock feeds by category of livestock;

c) public stock demand;

d) private stock demands;

e) seed demand.

3. International Trade Component

This component's primary purpose is to interact with the domestic supply and demand component and project U.S. export of food grains, feedgrains, and soybeans. In addition imports for each of 19 regions in each of these categories are made where appropriate. Import projections for non-fed or low grade beef and feedgrains are also considered.

These three components are integrated to estimate prices, quantities produced, domestic consumption, exports, grain stocks and livestock breeding herd inventories for the appropriate commodity groupings listed. These projections are made on an annual basis.

Specification of the functional relations used to abstractly model the activities encompassed by the three components of the model is based on economic theory. It was found that specification of macro-economic supply and demand relations benefitted from a review of the underlying micro economic assumptions with regard to firm objective functions and production functions. This approach assisted in maintaining consistency in model supply and demand specifications and in obtaining properly defined interfaces between various model components. The international component of the model uses the basic theory of a multiple market equilibrium model. A number of assumptions and simplifications were developed in order to achieve a manageable foreign component for which data could be obtained for empirical estimating. The basic concept adopted for use in the foreign component is that of "excess demand."

Validation efforts seeking to establish if the model was an adequate representation of the perceived "real world" that could be used to satisfy the purpose of the modeling effort were conducted. These efforts were iterative and involved continual testing and refinement of the model.

Validation of the model was conducted for individual function specifications, for integrated subcomponents and for total model performance. Individual functions were specified, examined and selected with respect to consistency with theory, ability to pass statistical inference tests and goodness of fit. Measures of "tracking" ability (historic estimation accuracy) were calculated for the integrated model. Accuracy measures considered, include the coefficient of correlation, percentage error, mean squared error, average bias, maximum absolute error, several versions of Theil "U-coefficients", and the slope and intercept coefficients of observed values regressed on predicted values.

In addition to historical tracking ability the model was tested for its ability to forecast beyond the data period (1950-71) within which it was estimated. It was discovered that for the model to effectively forecast outside of its data period, several unique and inadequately modeled exogenous shocks had to be adjusted to achieve satisfactory projections. Once such adjustments were made relatively satisfactory forecasts followed. The fact that these adjustments allowed the model to approximate 1972-75/conditions in U.S. agriculture, provides evidence that the unprecedented changes in agricultural prices observed in this period are largely due to changing exogenous influence and are not due to structural change in the agricultural sector.

The model was examined with respect to its dynamic properties in several ways. First, "steady state" runs were conducted to examine the stability of the model in the absence of exogenous shocks and the cyclical properties of the model. The model was found to display reasonable cyclical properties for livestock supply. Magnitudes of the cycles were deemed reasonable as were cycle lengths, though not precisely as expected. The model demonstrated slightly explosive tendencies under steady state exogenous conditions tested.[1] These tendencies present no problem in making short to intermediate term projections because of their slowness in developing. Also, dynamic responses simulated by the model for various "exogenous shocks" were observed as a test of the model's dynamic properties. In all "shocks" tested, stabilizing responses of a reasonable pattern and magnitude were observed. Interesting insight and understanding of the agricultural sector were obtained from the analyses of several of these "shocks". The concept of a "conditional dynamic multiplier" (as opposed to more traditional impact and dynamic multiplier concepts) developed for analyzing responses of the model, is felt to have useful application as a policy and comparative forecasting tool.

Briefly, some of the observations, understanding and conclusions gleaned from the validation oriented "exogenous shock" analyses are the following:

1) Dramatic declines in the magnitude and duration of shock effects occur when government stock levels and policies of a nature similar to those existing 1960's are simulated.
2) The lack of reserve stocks for soybeans appears to generate unstable market conditions not observed for wheat and feedgrains.
3) Exogenous shocks to either the crop or livestock subsector import significant short-run and long-

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[1]It is possible that certain sets of exogenous conditions will lead to stable dynamic properties while others will not.

run effects throughout the agricultural sector.

4) Dynamic impacts of direct or indirect shocks on livestock production activities require seven or more years before the majority of adjustment response is completed.

5) Policies, weather, production costs etc., that affect either feedgrain or high protein feed production and/or prices lead to alternations of livestock rations and production levels which are specific for each livestock category. Protein intensive livestock production is affected differently than roughage intensive livestock production.

Possible Areas of Continued Model Development

In the process of developing the initial NASS model several areas of consideration were deleted to avoid model complexity. As work proceeded it became evident that additional components and considerations would be useful in various sections of the model. The following discussion attempts to outline perceived current weaknesses of the model and areas where expanded scope could readily be undertaken which would lend added capabilities to the model's present analytical capacity.

Weaknesses of Present Model Performance

Several areas of relative weaknesses are observed in the model's historical tracking ability. Perhaps the most important of these is its ability to simulate grain stock. The stock models pick up the proper general pattern of stock holdings but lack precision in terms of level and magnitude of change predicted. Two approaches for modeling stocks were attempted. The first approach was to treat stocks as a residual. The second approach recognized a separate self motivating source of demand for stocks. A resolution of the appropriate approach was never entirely established. Attempts to theoretically derive a stock model and to follow such guidelines did not lead to an entirely satisfactory model, hence serious pragmatic deviations from theory appear in the final functions used. Further study to more precisely specify stock models appears warranted.

Weather, the continual specification problem of most crop supply analysis, is dealt with inadequately. Specific variables for each crop affecting planting, yield and acres abandoned should be developed. In the past, weather proxies have tended to center upon factors that influence yields.

The only widely available weather data series known to the author that would possibly be amendable to developing crop specified and yield-planting harvest specific weather impact proxies, is the U.S.D.A. monthly and state pasture condition index. This index has been used in the NASS model as a weather proxy but only in a general sense. No crop specific and yield-planting-harvest specific aggregation of the series has been attempted.

Weakness appears in the model with regard to its ability to properly simulated cyclical behavior in the livestock sector. Cyclical behavior is simulated for livestock production and the cycles have a likeness to historical cycles, but further "tuning" of the

precise cyclical nature of each livestock type would be useful.

Lastly, efforts should be made to improve the computer software used to access and update the model and to maintain a supporting data base. Numerous software options for using the model to conduct projections and policy analysis have been developed, but they remain relatively specific in nature and are in FORTRAN code. Such software options are useable by one familiar with FORTRAN code, but they require time to be comprehended and for coded access messages to be developed. Such inconveniences could be eliminated and greater flexibility in the use of the model could be achieved by further efforts in software development.

Analytical Capabilities Desired but Lacking

A number of currently relevant policy questions and forecasting issues have come to light which are of interest but are not adequately considered by the present model structure. Many of the issues the model is felt incapable of properly analyzing deal with responses of an agricultural sector relatively free of government control. For example, what would be the response to an export shock in a relatively free market situation for agricultural commodities? what would be the effect of raising or lowering "target prices" which exist in the present policy programs for crops?

The crop supply portion of the model is the major component limiting the model's ability to consider "government free" market responses. Presently, observations of the U.S. crop sector in a relative free market setting are insufficient to construct an econometrically estimated model of free market response for crop supply. It is felt however, that subjective modifications could be made to the crop supply response functions which would be quite reflective of free market crop supply response. Such adjustments would then make the model capable of analyzing relatively free market responses.

The procedure involved in subjectively developing a free market crop supply model would consist of replacing the "effective price support" variable presently used with a price expectation variable of an equivalent degree of certainty. Price support levels were known in advance by producers and any of proxy of expected price, to be made equivalent, would have to be discounted by some uncertainty factor.

Prices of non-agriculturally produced inputs, with the possible exception of fertilizer, are weakly considered in the present model. This is largely due to the fact that historical data dealing with response to non-agricultural produced inputs are inadequate. During the 1950's and 1960's non-agriculturally produced input prices were relatively stable, thus there has been no opportunity to observe responses to price changes for such inputs. Recently, changes of significant magnitude for fuel, fertilizer, machinery costs and capital costs have occurred. Undoubtedly they have had an impact on the agricultural sector.

The model does not deal with most consumer policy issues such as the effect of food stamps and other income redistribution programs. All demand equations are presently specified at the farm level and thus no account is taken of changes in the processing and distribution system.

No direct consideration is given in the model to land use related questions such as zoning, land speculation effects upon land price, land taxes, etc. Environmental laws affecting land use are also not considered.

Possible Areas of Model Expansion

Possible areas of future development and expansion of the model which should be considered include the following: 1) foreign competition in international grain markets; 2) quarterly analysis of livestock supply and demand; 3) supply and demand of roughages; 4) supply and demand of other agricultural commodities including further development of the cotton model and consideration of rice, tobacco, peanuts, fruits, vegetables, fish and mutton production; 5) a more detailed analysis of dairy and soybean joint and by-product markets; 6) farm level-retail level demand interrelations.

Foreign Competition

At present the supply and demand conditions and export policies of foreign nations which compete with U.S. grain exports are exogenously proxied by inclusion of an implicit price variable. Considerably more realism and analytical capability could be provided for the foreign component of the model by developing the international grain market simulation procedure to endogenously consider international market competition factors.

Quarterly Livestock Models

In order to adequately deal with the problems of simulating dynamic livestock supply response, it is felt that a quarterly model is needed. A quarterly model presents very little conceptual or technical difficulty in the livestock market, but it does complicate the interface between the livestock and feedgrain market. Utilization figures for feedgrain by quarters are not specific by source of utilization. Maintaining a quarterly feedgrain utilization model would then be difficult. In turn, deriving quarterly grain prices necessary to the specification of quarterly livestock supply models, would be difficult.

In developing shorter term livestock supply models, consideration should be given to animal population cohort models and biological factors as well as economic factors affecting the pattern of livestock supply.

Roughage Supply and Demand

Roughage production and demand is considered in the model through the modeling of silage supplies and the effect of pasture conditions on non-fed beef slaughter. Major emphasis in the model, however, is on feedgrain and protein feed supply and demand. This would appear to be somewhat of an imbalance in emphasis given the recent importance of grass-fed beef production practices and the general observation that over 50 percent of the feed intake (expressed in corn equivalents) by animals in the U.S. is in the form of pasture, hay, silage or other forage.

Other Commodity Categories

Several categories of agricultural commodities are not considered in the present modeling effort in order to focus upon grain-oilseed-livestock. It has become evident that some interactions of importance to the grain-oilseed-livestock markets extend to other commodities. Such extensions include the impact of cotton acreage on feedgrain and oilseed supply and the interface between wheat and rice supply and demand, particularly in the international market.

Peanuts, cotton, fruits and vegetables warrant consideration because of their importance in generating farm revenue. In addition peanuts and tobacco have significant policy influences upon their production resulting in a need for policy information generating study. Similarly fruits and vegetables provide questions in the area of migrant labor laws, collective bargaining and vertical integration.

Milk and Soybean Joint Products

Further consideration of all farm production and processing activities for milk and soybeans appears warranted on several points. The processing and marketing of these two products is perhaps the most complex of any agricultural product. In addition, the joint and by-product relationships and the resulting price formation processes for both milk and soybean products are directly influenced by policy actions.

Farm-Retail Linkages

Endogenous consideration of the activities involved in transforming farm commodities into retail products would serve to more closely link farm level demand with macro economic conditions and policies affecting food processing and consumer demand. Many of the issues facing agriculture today deal with food processing and marketing activities beyond the farm gate. Factors which affect processing firms in turn affect the derived demand for farm commodities.

Objectives in Perspection

The preceding summary of modeling efforts completed serve to point out that the task undertaken is felt to have been significant and worthy. The initial objective of developing an econometric-simulation model to assist in analyzing and projecting the intermediate and long-term effects of changing domestic and international market condition on the grain, livestock and oilseed subsectors of the United States is felt to have been accomplished. The model's full potential as an analytical tool depends on the ability of users to both learn from the model and in turn in corporate their understanding and knowledge into further development of this or other models.

The model should be viewed as a tool to be used for learning and understanding, and not as a self contained entity with which to make forecasts. Improved understanding can be obtained by examining the objectivity of model in relation to personal forecast perceptions. Only through the integration of the model, man and perceptions of reality can continued understanding and hence insight into the future come.

It is hoped that the model designed here can provide some initial commonly defined grounds and set of concepts conducive to the development of better perceptions of reality. Modeling forces the definition of concepts of reality in such a way that they are readily tested and transferable to others for subsequent testing and learning. If the modeling effort reported here has done this, then it has accomplised its goals.

It is hoped that many would challenge the model's projection capabilities and contrast them to their own concepts. To those who do and who find, like the author has, that the concepts and methods embodied in the model are worthy but capable of improvement, there exists a challenge; a challenge to improve their understanding of agriculture and transform that understanding into the content of this and other models so that others might be able to better use models in developing their understanding of United States agriculture.

APPENDICES

APPENDIX A

A LISTING OF KEY LITERATURE REVIEWED

The following is a listing of literature, by major category, which was reviewed in the process of formulating the conceptual nature of the model. The literature listed generally consists of articles dealing with the methodology and results of estimating supply and demand relations. The literature is by no means comprehensive but is rather a listing of items found most informative in the literature review process. It is hoped that this list will be helpful to those seeking examples of previous model specifications in any of the categories listed.

Beef

Crom, Richard, "A Dynamic Price-Output Model of the Beef and Pork Sector," USDA, Economic Research Service, Technical Bulletin, No. 1426, 1970.

Egbert, Alvin C. and Reutlinger, Shlomo, "A Dynamic Long-run Model of the Livestock-Feed Sector," a paper presented at the American Farm Economic Association Annual Meeting; Stillwater, Oklahoma, August, 1965.

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Hassler, James B., "The U.S. Feed Concentrate-Livestock Economy's Demand Structure, 1949-59," Nebraska Research Bulletin Number 203, University of Nebraska, Lincoln, October, 1962.

Kulshreshtha, S.N., Wilson, A.G. and Brown, D.N., "An Econometric Analysis of the Canadian Cattle-Calves Economy," Department of Agricultural Economics, University of Saskatchewan Technical Bulletin Number 101, Saskatoon, Canada, August, 1971.

Langemeier, Larry and Thompson, R.G., "Demand, Supply, and Price Relationships for the Beef Sector, Post-World War II Period," Journal of Farm Economics, 49:169-183, 1967.

Petit, Michel Jean, "Econometric Analysis of the Feed-Grain Livestock Economy," An unpublished Ph.D. Dissertation, Department of Agricultural Economics, Michigan State University, 1964.

Reimer, Eddy W. and Kulshreshtha, Surendra, N., "Forecasting Livestock Production and Feed Grains Demand," Department of Agricultural Economics, University of Saskatchewan Technical Bulletin Number BL:74-04, Saskatoon, Canada, February, 1974.

Trierweiler, John E. and Hassler, James B., "Orderly Production and Marketing in the Beef-Pork Sector," University of Nebraska Research Agricultural Experiment Station Bulletin No. 240, Lincoln, Nebraska, November, 1970.

Unger, Samuel G., "Simultaneous Equations System Estimation: An Application in the Cattle-Beef Sector," An unpublished Ph.D. Dissertation, Department of Agricultural Economics, Michigan State University, 1966.

Pork

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Petit, Michel Jean, "Econometric Analysis of the Feed-Grain Livestock Economy," An Unpublished Ph.D. Dissertation, Department of Agricultural Economics, Michigan State University, 1964.

Dairy

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Wilson, Robert R., "Demand, Supply, and Price Relationships for the Dairy Sector, Post-World War II Period," Journal of Farm Economics, 49:360-371, May, 1967.

Poultry

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Gerra, Martin J., "The Demand, Supply and Price Structure for Eggs," U.S.D.A. Agricultural Marketing Service, Technical Bulletin Number 1204, November, 1959.

Goto, N., Wolford, J.H. and Larzelere, H.E., "Egg Price Prediction Model for the Japanese Egg Industry," Reprinted from Japanese Poultry Science, Volume 11, No. 1, January, 1974, pp. 10-16.

Hartman, David G., "The Egg Cycle and the Ability of Recursive Models to Explain It," American Journal of Agricultural Economics, Volume 56, Number 2 (May, 1974) pp. 254-262.

Roy, Sunit K. and Johnson, Phillip N., "Econometric Models for Quarterly Shell Egg Prices," American Journal of Agricultural Economics, Volume 55, No. 2 (May, 1973) pp. 209-213.

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Meinken, Kenneth W., "The Demand and Price Structure for Wheat," U.S.D.A. Economic Research Service Technical Bulletin No. 1136, March, 1955.

Mo, William Y., "An Economic Analysis of the Dynamics of the United States Wheat Sector," U.S.D.A. Economic Research Service Technical Bulletin Number 1395.

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Vandenborre, R.J., "An Econometric Analysis of the Market for Soybean Oil and Soybean Meal," University of Illinois College of Agriculture, Agricultural Experiment Station Bulletin 723, Urbana, Illinois, March, 1976.

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McKeon, John, "Farm Commodity Programs: Their Effect on Plantings of Feed Grains and Soybeans," An unpublished Ph.D. Dissertation, Michigan State University, 1974.

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Reimer, Eddy, W. and Kulshreshtha, Surendra N., "Forecasting Livestock Production and Feed Grains Demand: An Econometric Analysis of Canadian Livestock-Feed Grains Sector," Department of Agricultural Economics Technical Bulletin Number BL:74-04, University of Saskatchewan, Saskatoon, Canada.

Cotton

Barlowe, Russell and Donald, James, "Analysis of Demand for U.S. Cotton Exports," Cotton Situation, CS-252 (August, 1971).

International Trade

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Samuelson, Lee, "A New Model of World Trade," OECD Economic Outlook: Occasional Studies (December, 1973).

Taplin, Grant B., "Models of World Trade," I.M.F. Staff Papers (November, 1967).

APPENDIX B

DATA LISTING AND DESCRIPTION

All domestic functions of the National Agricultural Model are estimated from 121 basic sets of time series data. These series are aggregated in various ways to form numerous other variables such as ratios, products, sums, weighted variables, etc. A listing of all basic endogenous and exogenous domestic variables complete with source reference and discription of each is included in this appendix.

The procedure used in describing the variables is as follows: (1) variables are classified as endogenous or exogenous; (2) each variable is identified by a descriptive name, phonetic code name, and the computer program vector location designation[1]; (3) following the above information a source listing for the variable is given; and (4) a short description of the variable with regard to definition, transformations involved in obtaining the value, etc. is presented.

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[1]All basic endogenous or exogenous variables are stored in one of two double subscripted arrays in the model program. The arrays are titled ENVEC which contain all variables endogenous to the simultaneous subcomponent of the model (which is not all enclusive of endogenous variables in the model) and EXVEC which contains all variables exogenous to the simultaneous subcomponent of the model (some variables exogenous to this subcomponent are endogenous to the whole model). The first subscript refers to a variable identification number while the second subscript refers to the time period of the variable and is used to index lagged variables where 1 is associated with $t + 1$ and 2 with t, 3 with $t - 1$ etc.

All references to data are in the context of those definitions used in the model program. Code sheets, supporting programs, etc. used in the project may contain similar data series of different definition.

Several general definitions are given at this point to simplify the description process in the immediately following data definition listing. All of the following definitions when used will be denoted by quotation marks.

General Definitions

Crop Year

The year beginning in October and ending in September is referred to as the "crop year". Crop years for specific crops may vary and will be referred to by name i.e., wheat crop year. Definitions of specific crop years are given in the publication Agricultural Statistics.

Ton

Unless otherwise specified ton will refer to a U.S. ton weight of 2,000 pounds. A metric ton consists of 2204.6 pounds or 1.1023 U.S. tons.

Feedgrain

An aggregation of corn, oats, barley and grain sorghum by weight, where a bushel of corn is 56 pounds, a bushel of oats 32 pounds, a bushel of barley 48 pounds and a bushel of grain sorghum 56 pounds.

Soybean meal or meal equivalents

A bushel of soybeans is assumed to yield 47.5 pounds of meal and 10.9 pounds of oil. Other protein feeds are often transformed into soybean meal equivalents on the basis of protein content. Forty-four percent is the base percentage typically used.

Ratio Transformation Updating

In cases where a change in data definition over time makes it necessary to convert two or more series of data into one continuous consistent series, a common technique used was the following: Ratios of the two series were calculated for periods during which the series overlap; the average ratio of the overlapping periods was then used to convert the older series to a comparable basis to the new.

High Protein Feeds

Any product of agricultural or marine origin containing a minimum of 20 percent crude protein. The measure for the quantity of this type of feed is expressed in 44 percent soybean meal equivalents. In practice this category is made up primarily of soybean meal, followed by cotton seed meal, linseed meal and fish meal.

Effective Support Price

Crop price support operations by the government during the 50's and 60's were comprised of a support price and acreage diversion program. Houck and Ryan in an article entitled "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," published in the American Journal of Agricultural Economics, May 1972, develop a formula to describe the various support and acreage restriction operations in effect through the 50's and 60's. Subsequent use of the formula by John McKeon in his dissertation "Farm Commodity Programs; Their Effect on Plantings of Feed Grains and Soybeans" developed the data used here. McKeon's thesis appendix should be consulted for illustrations of the use of the formula to be presented here. The formula is as follows:

$$PVI = \gamma PA$$

where

PVI = Effective Support Price

γ = An adjustment factor reflecting planting restrictions

PA = Announced support price

<u>Effective Diversion Payment</u>

Houck and Ryan also developed in addition to their formula for "effective support prices" a formula to describe crop acreage diversion programs. Acreage diversion programs generally consisted of a payment to divert acreage which varied according to the amount of land diverted. MeKeon also applied this formula in his dissertation and illustration of its use can be found in the appendix of his dissertation. The formula is as follows:

$$PV2 = wPR$$

where

PV2 = Effective Diversion Payment

w = Proportion of acreage eligible for the diversion payment

PR = Payment rate for diversion

BASIC ENDOGENOUS VARIABLES

Simultaneously Estimated Endogenous Variables

Feedgrain Consumption by Pork (1,000 tons)

PORKFG -- ENVEC (1,T)
<u>Livestock - Feed Relationships; National and State</u>. Economic Research Service: United States Department of Agriculture, Washington, D.C.

"Crop Year" consumption of "feedgrains" by all pork including breeding stock and barrows and gilts for slaughter. Definitional changes for data reproted prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Pork (1,000 tons)

PORKHPC -- ENVEC (2,T)
Source and remarks are the same as above.

Feedgrain Consumption by Fed Beef (1,000 tons)

FBEFFG -- ENVEC (3,T)
Livestock and Feed Relationships; National and State.

"Crop year" consumption of "feedgrains" by steers and heifers on feed. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71

High Protein Feed Consumption by Beef (1,000 tons)

FBEFHP -- ENVEC (4,T)
Source and remarks are the same as above.

Feedgrain Consumption by non-fed Beef (1,000 tons)

NFBEFFG -- ENVEC (5,T)
Livestock and Feed Relationships, National and State.

"Crop year" consumption of "feedgrain" by all types of beef except "fed beef" as previously defined, hence cows, calves, bulls, etc. are included. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Non-Fed Beef (1,000 tons)

NFBEFHP -- ENVEC (6,T)
Source and remarks are the same as above.

Feedgrain Consumption by Dairy Cows (1,000 tons)

MILKFG -- ENVEC (7,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by dairy cows. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Dairy Cows (1,000 tons).

MILKHP -- ENVEC (8,T)
Source and remarks are the same as above.

Feedgrain Consumption by Dairy Heifers and Bulls (1,000 tons)

DHEIFFG -- ENVEC (9,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by dairy cattle other than milk cows, i.e. all replacement stock and dairy bulls. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Dairy Heifers and Bulls (1,000 tons)

DHEIFHP -- ENVEC (10,T)
Source and remarks are the same as above.

Feedgrain Consumption by chickens (1,000 tons)

CHICKFG -- ENVEC (11,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by broilers. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Chicken (1,000 tons)

CHICKHP -- ENVEC (12,T)
Source and remarks are the same as above.

Feedgrain Consumption by Turkeys (1,000 tons)

TURKFG -- ENVEC (13,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by turkeys produced for slaughter and the turkey breeding flock. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-1971.

High Protein Feed Consumption by Turkeys (1,000 tons)

TURKHP -- ENVEC (14,T)
Source and remarks are the same as above.

Feedgrain Consumption by Poultry Layer Flocks (1,000 tons)

EGGFG -- ENVEC (15,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by hens and pullets and other mature chickens used for producing table eggs or hatchery eggs. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

High Protein Feed Consumption by Poultry Layer Flocks (1,000 tons)

EGGHP -- ENVEC (16,T)
Source and remarks are the same as above.

Total Feedgrain Consumption by all Livestock (1,000 tons)

GRAINCON -- ENVEC (17,T)
Livestock and Feedgrain Relationships, National and State.

"Crop year" consumption of "feedgrain" by all livestock. In addition to feedgrain consumption by categories of livestock listed in the first sixteen data definitions, i.e. fed beef, non-fed beef, pork, dairy cows, dairy heifers, chickens, turkeys, and egg producing poultry; the following categories are also included, sheep, horses and mules, other livestock and unallocated livestock feed including waste and other losses. Definitional changes for data prior to 1959 necessitated "ratio transformation" procedures. Data available from 1940-71.

Total High Protein Feed Consumption by all Livestock (1,000 tons)

HPCON -- ENVEC (18,T)
Source and remarks are the same as above.

Corn Used for Seed (1,000 tons)

CSEED -- ENVEC (19,T)
Agricultural Statistics. United States Department of Agriculture, U.S. Government Printing Office, Washington, D.C.

Quantity of corn estimated to be used in planting next years corn crop. Data available from 1950-71.

Oats Used for Seed (1,000 tons)

OSEED -- ENVEC (20,T)
Source and remarks are the same as above.

Barley Used for Seed (1,000 tons)

BSEED -- ENVEC (21,T)
Source and remarks are the same as above.

Sorghum Used for Seed (1,000 tons)

SHSEED -- ENVEC (22,T)
Source and remarks are the same as above.

Wheat Used for Seed (1,000 tons)

WHSEED -- ENVEC (23,T)
Source and remarks are the same as above.

Soybeans Used for Seed (1,000 bushels)

SBSEED -- ENVEC (24,T)
Source and remarks are the same as above.

Government Stocks of Feedgrain (1,000 tons)

GSTKFG -- ENVEC (25,T)
<u>Agricultural Statistics</u>.

The summation by weight of corn, oats, barley, and sorghum as held at the end of each crop's respective crop year by the government. Data available from 1950-71.

Private Stockss of Feedgrain (1,000 tons)

PSTKFG -- ENVEC (26,T)
<u>Agricultural Statistics</u>.

The summation of weight of corn, oats, barley and sorghum as held at the end of each crop's respective crop year by non-government sources. Data available from 1950-71.

Government Stocks of Wheat (1,000 tons)

GSTKWH -- ENVEC (27,T)
<u>Agricultural Statistics</u>.

The quantity of wheat stocks held at the end of the "wheat crop year" by the government. Data available from 1950-71.

Private Wheat Stocks (1,000 tons)

PSTKWH -- ENVEC (28,T)
<u>Agricultural Statistics</u>.

The quantity of wheat stocks held at the end of the "wheat crop year" by non-government sources. Data available from 1950-71.

Soybean Stocks (1,000 tons)

SBSTK -- ENVEC (29,T)
Agricultural Statistics.

The quantity of soybean stocks held at the end of the "soybean crop year" by both government and private sources. (Government holdings have historically been non-existent or very small.) Data available from 1950-71.

Wheat Consumed by Humans (1,000 tons)

WHTFOOD -- ENVEC (30,T)
Agricultural Statistics.

Utilization of wheat during the wheat "crop year" for domestic food use. Data available from 1950-71.

Wheat Fed to Livestock (1,000 tons)

WHTFED -- ENVEC (31,T)
Agricultural Statistics.

Utilization of wheat during the wheat "crop year" for livestock feed. Data available from 1950-71.

Miscellaneous Feedgrain Utilization (1,000 tons)

MISCFG -- ENVEC (32,T)
Agricultural Statistics

Utilization of feedgrains during the "feedgrain crop year" for miscellaneous uses, including breakfast food and cereal production, alcoholic distillates, etc. Data available from 1950-71.

Feedgrain Imports (1,000 tons)

FGIMP -- ENVEC (33,T)
Agricultural Statistics.

Imports of feedgrains and feedgrain products, i.e. alcoholic beverages, in feedgrain equivalents during the "feedgrain crop year". Data available from 1950-71.

Wheat Exports (1,000 tons)

WHTEX -- ENVEC (34,T)
Agricultural Statistics.

Exports of wheat and wheat flour expressed in wheat equivalents during the "wheat crop year". Data available from 1950-71.

Soybean Exports (1,000 tons)

SOYEX -- ENVEC (35,T)
Agricultural Statistics.

Exports of soybean meal and soybeans expressed in meal equivalents during the "soybean crop year". Data available from 1950-71.

Feedgrain Exports (1,000 tons)

FGEX -- ENVEC (36,T)
Agricultural Statistics.

Exports of feedgrains during the respective "feedgrain crop years". Data available from 1950-71.

Corn Price ($/bu.)

CORNP -- ENVEC (37,T)
Agricultural Prices, Annual Summaries; Crop Reporting Board, Statistical Reporting Service, United States Department of Agriculture, Washington, D.C.

Average "corn crop year" price received by farmers for all grades of corn sold. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets. Bureau of Agricultural Economics, United States Department of Agriculture.

Soybean Meal Price ($/cwt)

SOYMP -- ENVEC (38,T)
Agricultural Prices.

Average "crop year" price paid by farmers for 44% bulk soybean meal. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Wheat Price ($/bu.)

WHTP -- ENVEC (39,T)
Agricultural Prices.

Average "wheat crop year" price received by farmers for all grades of wheat sold.' Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Pork Price ($/cwt.)

PORKP -- ENVEC (40,T)
Agricultural Prices.

Average "crop year" price received by farmers for all grades of pork slaughtered. An average "crop year" price was computed by weighting monthly prices received for pork by monthly federally inspected slaughter levels of barrows and gilts. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Fed Beef Price ($/cwt.)

FBEFP - ENVEC (41,T)
Agricultural Prices.

Average "crop year" price received by farmers for steers and heifers slaughtered. An average "crop year" price was computed by weighting monthly prices received for steers and heifers by the monthly total weight of federally inspected steer and heifer slaughter. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Non Fed Beef Price ($/cwt.)

NFBEFP -- ENVEC (42,T)
Agricultural Prices.

Average "crop year" price received by farmers for cull beef and dairy cows slaughtered. An average "crop year" price was computed by weighting monthly prices received by farmers for cows by the monthly total weight of federally inspected cow and bull slaughter. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Milk Price ($/cwt.)

MILKP -- ENVEC (43,T)
Agricultural Prices.

Average "crop year" price received by farmers for all grades of milk sold to all plants. An average "crop year" price was computed by weighting monthly prices received by farmers for milk by monthly milk production as reported in the "Dairy Situation" annual summaries. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Chicken Price (cents/lb.)

CHIKP -- ENVEC (44,T)
Agricultural Prices.

Average "calendar year" price received by farmers for broilers on a liveweight basis. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Turkey Price (cents/lb.)

TURKP -- ENVEC (45,T)
Agricultural Prices.

Average "calendar year" price received by farmers for turkeys on a liveweight basis. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Egg Price (cents/dozen)

EGGP -- ENVEC (46,T)
Agricultural Prices.

Average "calendar year" price received by farmers for eggs. Data is available from 1947-73. Prior to 1954 is from Crops and Markets.

Non-fed Beef Imports

NFBEFIM -- ENVEC (47,T)
Livestock and Meat Statistics.

All beef imported is assumed to be low quality or non-fed beef. Data is collected on a carcus weight basis but is converted to liveweight before use by a conversion factor of 2.0, i.e., the dressing percentage is assumed to be 50 percent. Imports are on a calendar year basis. Data available from 1950-72.

Oat Price ($/bu.)

OATP -- ENVEC (48,T)
Agricultural Prices.

Average "Oat crop year" price received by farmers for all grades of oats. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Barley Price ($/bu.)

BARP -- ENVEC (49,T)
Agricultural Prices.

Average "barley crop year" price received by farmers for all grades of barley. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Grain Sorghym Price ($/cwt.)

SORHP -- ENVEC (50,T)
Agricultural Prices.

Average "sorghum crop year" price received by farmers for all grades of sorghum. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Soybean Price ($/bu.)

SOYBP -- ENVEC (51,T)
Agricultural Prices.

Average "soybean crop year" price received by farmers for all grades of soybeans. Data is available from 1947-73. Prior to 1954 data is from Crops and Markets.

Feedgrain Export Price ($/ton)

FGEXP -- ENVEC (52,T)
Agricultural Prices.

Refer to Michigan State University National Agricultural Sector Study International Data Bank data listing for source and precise definition.

Wheat Export Price ($/ton)

WHTEXP -- ENVEC (53,T)

Refer to Michigan State University National Agricultural Sector Study International Data Bank data listing for source and precise definition.

Soybean Export Price ($/ton)

SOYBEXP -- ENVEC (54,T)

Export price of soybean expressed in 44 percent meal equivalents. Refer to Michigan State University National Agricultural Sector Study Data Bank data listing for source and precise definition.

Cotton Price (cents/lb.)

COTTONP -- ENVEC (55,T)
Agricultural Prices.

Average "cotton crop year" price received by farmers. Data is available from 1950-73.

Recursively Estimates Endogenous Variables

Soybean Production (1,000 bu.)

SOYBQ -- ESVEC (20,T)
Agricultural Statistics.

Total production fo soybeans. Data available from 1950-73.

Pork Production (millions of lbs.)

PORKQ -- EXVEC (25,T)
Livestock and Meat Statistics.

Total "crop year" liveweight slaughter of barrows, gilts, and sows. Determined by adding monthly commercial slaughter from October to September and allocating annually reported farm slaughter of pork to each month of the year according the percent of total calendar slaughter during that month. Hence the total figure includes both commercial and farm slaughter for the crop year. Data available from 1950-73.

Fed Beef Production (millions of lbs.)

FBEFQ -- EXVEC (26,T)
Livestock and Meat Statistics.

Total "crop year" liveweight slaughter of steers and heifers. Determination of a crop year liveweight steer and heifer slaughter figure involved the use of several monthly series of data and annual data series. Federally inspected slaughter is reported by type, (steers, heifers, calves, cows, bulls, and stags). The number and dressed weight are reported for each category. Since liveweight is desired here average monthly liveweights of steers and heifers in seven major markets are used in conjunction with monthly federally inspected numbers of steers and heifers slaughtered to calculate a monthly federally inspected liveweight slaughter figure for steers and heifers. A similar procedure is used to determine monthly federally inspected liveweight slaughter of cows. Non-federally inspected liveweight slaughter is reported annually and does not distinguish between cows and bulls versus steers and heifers. Hence non-federally inspected slaughter is first allocated between fed and non-fed beef categories based upon the ratio of fed and non-fed beef federally inspected slaughter. Following this allocation, annual total non-federally inspected slaughter is allocated to each month of the calendar year for each category (fed beef and non-fed beef) according to the percentage of total annual federally inspected slaughter for the category occurring in that month.

A computer routine has been established to perform these transformations given the proper raw data series. All raw data needed is alluded to above and is in the annual Livestock and Meat Statistics bulletin.

Non-fed Beef Production (million lbs.)

NFBEFQ -- EXVEC (27,T)
Livestock and Meat Statistics.

Total "crop year" liveweight slaughter of cows, bulls and stags. The previous explanation of the derivation of Fed Beef production data covers the computations involved in transforming various raw data to this particular data definition. Data is available from 1950-73.

Milk Production (million lbs.)

MILKQ -- EXVEC (28,T)
Milk, Crop Reporting Board of the Statistical Reporting Board of the United States Department of Agriculture, Washington, D.C.

Total "crop year" production of all fluid milk derived by summing monthly figures. Data is available from 1945-73.

Dairy Heifers (1,000 head)

DHEIF -- EXVEC (29,T)
Livestock and Meat Statistics.

Number of dairy heifers 500 pounds and over on farms January 1. Prior to 1965 this series was defined as dairy heifers 1-2 years old on farms January 1. "Ratio transformations" were used to transform data prior to 1965 to a comparable basis. Data is available from 1950-71.

Dairy Cows (1,000 head)

DCOW -- EXVEC (30,T)
Livestock and Meat Statistics.

Number of dairy cows and heifers that have calved on farms January 1. Prior to 1965 this series was defined as cows and heifers two years and older kept for milk and on farms January 1. "Ratio transformations" were used to transform data prior to 1965 to a comparable basis. Data is available from 1950-71.

Beef Cows (1,000 head)

BFCOW -- EXVEC (31,T)
Livestock and Meat Statistics.

Number of beef cows and heifers that have calved on farms January 1. Prior to 1965 this series was defined as beef cows and heifers over two years old on farms January 1. "Ratio transformations" were used to transform data prior to 1965 to a comparable basis. Data is available from 1950-71.

Sows Farrowed in the Spring (1,000 head)

SOWFS -- EXVEC (32,T)
Hogs and Pigs, Economic Research Service, United States Department of Agriculture, Washington, D.C.

Number of sows farrowing between December and May. (Dated according to the crop year starting in the preceding October.) Data is available from 1950-71.

Sows Farrowed in the Fall (1,000 head)

SOWFF -- EXVEC (33,T)
Hogs and Pigs.

Number of sows farrowing between June and November of the crop. (Dated according to the crop year starting during October of this period.) Data is available from 1950-71.

Chicken Production (million lbs.)

CHIKQ -- EXVEC (34,T)
Poultry and Egg Statistics. Economic Research Service, United States Department of Agriculture, Washington, D.C.

Total commercial broiler and mature chicken slaughter during the calendar year. Reported on a ready-to-cook weight basis. Data is available from 1960-71

Egg Produ-tion (million dozen)

EGGQ -- EXVEC (35,T)
Poultry and Egg Statistics.

Commercial egg production during the calendar year. Data is available from 1960-71

Turkey Production (million lbs.)

TURKQ -- EXVEC (36,T)
Poultry and Egg Statistics.

Total commercial turkey slaughter during the calendar year. Reported on a ready-to-cook weight basis. Data is available from 1960-71

Acres of Corn Planted (1,000 acres)

APC -- EXVEC (37,T)
Agricultural Statistics.

Data available 1950-73.

Acres of Oats Planted (1,000 acres)

APO -- EXVEC (38,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Barley Planted (1,000 acres)

APB -- EXVEC (39,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Sorghum Planted (1,000 acres)

APSH -- EXVEC (40,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Soybeans Planted (1,000 acres)

APSB -- EXVEC (41,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Wheat Planted (1,000 acres)

APWHT -- EXVEC (42,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Cotton Planted (1,000 acres)

APCT -- EXVEC (43,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Corn Harvested for Grain (1,000 acres)

AHC -- EXVEC (44,T)
Agricultural Statistics.

Corn is harvested for either grain, silage or forage. Acres planted minus the sum of these three forms of harvesting generated an unharvested or abandoned acres figure for corn. Corn production divided by acres harvested generated yield per acre figures. Data is available from 1950-73.

Acres of Corn Harvested for Silage (1,000 acres)

AHCS -- ESVEC (45,T)
Agricultural Statistics.

Corn silage production divided by acres of corn harvested for silage generates corn silage yield figures. Data is available from 1950-73.

Acres of Corn Harvested for Forage (1,000 acres)

AHCF -- EXVEC (46,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Oats Harvested (1,000 acres)

AHO -- EXVEC (47,T)
Agricultural Statistics.

Total production of oats divided by acres harvested generates oats yield figures. Unharvested acres of oats is defined as acres of oats planted minus acres of oats harvested. Data is available from 1950-73.

Acres of Barley Harvested (1,000 acres)

AHB -- EXVEC (48,T)
Agricultural Statistics.

Remarks are the same as above.

Acres of Sorghum Harvested for Grain (1,000 acres)

AHSH -- EXVEC (49,T)
Agricultural Statistics.

Sorghum is harvested for either grain, silage or forage. Acres planted minus the sum of these three forms of harvesting generates an unharvested or abandoned acres figure for sorghum. Sorghum production divided by acres harvested generates yield per acre figures. Data is available from 1950-73.

Acres of Sorghum Harvested for Silage (1,000 acres)

AHSHS -- EXVEC (50,T)
Agricultural Statistics.

Sorghum silage production divided by acres harvested generates sorghum silage yield figures. Data is available from 1950-73.

Acres of Sorghum Harvested for Forage (1,000 acres)

AHSHF -- EXVEC (51,T)
Agricultural Statistics.

Data available from 1950-73.

Acres of Wheat Harvested (1,000 acres)

AHWHT -- EXVEC (52,T)
Agricultural Statistics.

Total production of wheat divided by acres harvested generates wheat yield figures. Unharvested acres of wheat is defined as acres of wheat planted minus acres of wheat harvested. Data is available from 1950-73.

Acres of Soybeans Harvested (1,000 acres)

AHSB -- EXVEC (53,T)
Agricultural Statistics.

Remarks are the same as above.

Acres of Cotton Harvested (1,000 acres)

AHCT -- EXVEC (54,T)
Agricultural Statistics.

Remarks are the same as above.

Corn Production (1,000 bu.)

CORNQ -- EXVEC (55,T)
Agricultural Statistics.

Data available from 1950-73.

Corn Silage Production (1,000 tons)

CSILQ -- EXVEC (56,T)

Source and remarks are the same as above.

Oat Production (1,000 bu.)

OATO -- EXVEC (57,T)

Source and remarks are the same as above.

Barley Production (1,000 bu.)

BARQ -- EXVEC (58,T)

Source and remarks are the same as above.

Sorghum Production (1,000 bu.)

SORHQ -- EXVEC (59,T)

Source and remarks are the same as above.

Sorghum Silage Production (1,000 tons)

SSILQ -- EXVEC (60,T)

Source and remarks are the same as above.

Wheat Production (1,000 tons)

WHTQ -- EXVEC (61,T)

Source and remarks are the same as above.

Cotton Production (1,000 bales)

COTQ -- EXVEC (62,T)
Agricultural Statistics.

A bale is defined as 480 pounds during and after 1964 and 500 pounds prior to 1964. Data is available from 1950-73.

Silage Available for Feed Beef Consumption (1,000 tons of corn equivalents)

SILFB -- EXVEC (63,T)
Agricultural Statistics.

Corn silage and sorghum silage production are aggregated in terms of their corn equivalent feeding value to fed beef. A unit of corn silage equals .3 units of corn and a unit of sorghum silage equals .25 units of corn. Data available from 1950-73.

Silage Available for Non-Fed Beef Consumption (1,000 tons of corn equivalent)

SILNFB -- EXVEC (64,T)
Agricultural Statistics.

Corn silage production and sorghum silage production are aggregated in terms of their corn equivalent feeding value for non-fed beef. A unit of corn silage equals .18 units of corn and a sorghum silage unit equals .2 units of corn.

Basic Exogenous Variable

Short-term Interest Rates (percent)

INTEREST -- EXVEC (1,T)
Business Statistics, U.S. Department of Commerce, Washington, D.C.

Average annual prime 4-6 month commercial paper interest rate. Data is available from 1950-73.

Non-agricultural Wage Rate ($/hour)

PRIVWAGE -- EXVEC (2,T)
Business Statistics.

Average hourly gross earnings per non-white collar worker in private non-agricultural industry. Data is available from 1950-73.

Disposable Per Capita Income ($/person)

DPCI -- EXVEC (3,T)
Business Statistics.

Data is available from 1950-73.

United States Population (millions)

POP -- EXVEC (4,T)
Agricultural Statistics.

Population, both civilian and military as of July 1. Data is available from 1950-73.

Soybean Oil Price (cents/pound)

SOYOILP -- EXVEC (5,T)
Agricultural Statistics.

Price of Soybean oil at Decatur, Illinois on an average annual basis. Data is available from 1950-73.

Labor Efficiency in Chicken Production (hours/ unit of production)

CHIKLABE -- EXVEC (6,T)
Dr. John Ferris, Department of Agricultural Economics, Michigan State University.

Hours of labor required to produce a unit of broiler output. Data is available from 1950-73.

Fertilizer Price (Index)

FERTP -- EXVEC (7,T)
Agricultural Statistics.

Price paid by farmers for all fertilizer. Data is available from 1950-73.

Capital Cost (percent)

CAPP -- EXVEC (8,T)
Agricultural Statistics.

Annual equivalent rate implied by the 4-6 month prime commercial paper rate.

Farm Wage Rate ($/hour)

FARMWAGE -- EXVEC (9,T)
Agricultural Statistics.

Average hourly farm wage rate without room and board. Data is available from 1950-73.

Pasture Conditions (Index)

PASTCOND -- EXVEC (10,T)
Livestock and Meat Statistics.

Average May to October Pasture condition. Data is available from 1950-73.

Weather Condition at Planting (Rainfall in inches)

WEATHER3 -- EXVEC (11,T)
John McKeon, "Farm Commodity Programs, Their Effect on Plantings of Feedgrain and Soybeans," Unpublished Ph.D. dissertation, Michigan State University.

Rainfall during the wheat planting period.

"Effective Support Price" for Corn ($)

PVIC -- EXVEC (12,T)
Houck, J.P. and Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," American Journal of Agricultural Economics, Vol. 54, May 1971, and John McKeon, "Farm Commodity Programs, Their Effect on Plantings of Feedgrain and Soybeans". Data available from 1950-73.

"Effective Diversion Payment" for Corn ($)

PV2C -- EXVEC (13,T)

Source and remarks are the same as above.

"Effective Support Price" for Oats ($)

PV1O -- EXVEC (14,T)

Source and remarks are the same as above.

"Effective Support Price" for Barley ($)

PV1B -- EXVEC (15,T)

Source and remarks are the same as above.

"Effective Diversion Payment" for Barley ($)

PV2B -- EXVEC (16,T)

Source and remarks are the same as above.

"Effective Support Price" for Sorghum ($)

PV1SH -- EXVEC (17,T)

Source and remarks are the same as above.

"Effective Diversion Payment" for Sorghum ($)

PV2SH -- EXVEC (18,T)

Source and remarks are the same as above.

"Effective Support Price" for Soybeans ($)

PV1SB -- EXVEC (19,T)

Source and remarks are the same as above.

"Effective Support Price" for Wheat ($)

PV1WHT -- EXVEC (21,T)

Source and remarks are the same as above.

"Effective Diversion Payment" for Wheat ($)

PV2WHT -- EXVEC (22,T)

Source and remarks are the same as above.

"Effective Support Price" for Cotton ($)

PV1CT -- EXVEC (23,T)

Source and remarks are the same as above.

"Effective Diversion Payment" for Cotton ($)

PV2CT -- EXVEC (24,T)

Source and remarks are the same as above.

Consumer Price Index

CPI -- EXVEC (65,T)
Business Statistics.

Cotton Stocks (1,000 bales)

COTSTK -- EXVEC (66,T)
Agricultural Statistics.

Data available from 1950-73.

APPENDIX C-1

LIVESTOCK SECTOR SUPPLY RESPONSE FUNCTIONS

This appendix discusses the essential nature of the livestock slaughter and breeding herd functions estimated and used in the initial model specification. The specific interface mechanism between various livestock categories, breeding and slaughter relations, livestock and feed markets, etc. will be discussed with respect to interface properties unique to each case.

The equations presented diverge from the theoretical specification indicated in the methodology chapter. In the cases where serious divergence occurs the statistical and theoretical problems leading to this divergence will be discussed. Comments also are made with respect to logical consistency, statistical properties and performances of the functions within the model.

All references to elasticities in this appendix are to Table IV.1 in Chapter IV. Parameter values and statistical values for each function discussed are presented in a set of tables at the end of this appendix which are arranged in order of discussion and will not be alluded to in the text by number or title.

Pork

Two breeding herd relations, sows farrowed in the fall and spring, and an annual (crop year basis) pork slaughter function are estimated for the pork supply component of the model. These three functions are related by means of recursive links. That is, the fall sow farrowing estimate is made first; this estimated value then enters the spring farrowing function as an independent variable. The spring farrowing estimate in turn enters the slaughter function and next year's fall farrowing function. The slaughter function interacts with the livestock product demand component of the model to generate a pork price which, when lagged, becomes an input into pork breeding and slaughter functions.

Capital cost and labor cost proxies included in the theoretical specification as relevant variables for pork supply functions were found in general to be insignificant. The theoretical specification of a single enterprise objective function was discarded in the case of pork and a proxy (fed beef price received by farmers) for the competing enterprise beef was allowed to enter as a factor in sow farrowing estimates.

An alternative approach for the pork supply component was tested. This approach did not link the breeding and slaughter functions as previously described. Instead the variables, corn price, soymeal price, pork price, interest rate, wage rate and beef price were all included in the slaughter function in distributed lag models with no sows farrowed variable included. This approach essentially attempts to capture in one function, breeding herd adjustment effects as well as direct slaughter and feed adjustment impacts on pork production. This approach was found to generate overly sensitive responses in the integrated model simulations; hence the integrated breeding herd-slaughter function approach intitally outlined was adopted.

The major factors affecting both slaughter and farrowing are pork prices, corn prices and soymeal prices. The soymeal price appears particularly strong in the farrowing functions. As was expected, the lag structures were longer for the farrowing functions than the slaughter function. The presence of a sows farrowed variable in the slaughter function accounts for much of the long-run shift in production, hence the input and output price lag structures need only pick up shorter-run impacts such as changes in weight and rates of gilt withholdings from slaughter.

The spring sow farrowing equation presents some theoretical and statistical problems. The corn price lag structure has a weak average t-value of .96 and exhibits an unexpected positive sign on the first two periods in the lag. The positive sign on the first two periods of the corn price lag causes a positive response to corn price increases in the first two periods, but the total or long-run response is negative. A similar but less serious result is also found for the soymeal price variable in the spring farrowing function. A theoretical and intuitive justification was given in the methodology chapter for the appearance of opposite signs on early lag periods in slaughter functions. The same arguments and hypotheses do not appear reasonable in the case of breeding stock.

In general the length of the lags found to provide the best statistical properties and reasonable shapes were of three to four years in length. Subsequent simulation of the pork component in the

simulation model indicated that the nature of the integrated pork component produced a five year, slightly explosive pork cycle. It is believed that shortening the lag lengths slightly may speed up the simulation cycle and dampen the responses to provide a dampening four year cycle.

Fed Beef

Fed beef consists of steer and heifer slaughter. In estimating fed beef slaughter the number of beef and dairy cows present on January 1 of the preceding crop year is entered as a proxy for existing capacity in the beef industry. The cow numbers variable also effectively proxies long-run shifts in the beef industry and hence relatively short lags are expected and found for the other price variables in the slaughter relation. Attempts to weight beef cow and dairy cow numbers to give more importance to beef cows as opposed to simply summing the two numbers did not produce any added significance for the cow numbers variable.

Silage is entered into the fed beef function as a proxy for roughage inputs. Silage is entered as a quantity as opposed to a price on the argument that a very small market for silage exists. Most farmers produce their own silage and very little storage exists because of its physical nature. Hence, the production of silage in a given year determines a relatively fixed amount of silage available for the year. On this basis, theoretical arguments that asset fixity constraints should enter as quantities appear applicable for the silage variable.

Fed beef production and cow numbers have been very trended upward from the early 1950's to the present; hence a good fit as measured by R^2 is easy to obtain. Accurate individual parameter estimates are difficult to obtain because of a lack of non-trend variance in the data. Therefore, the regression equation seems to be able to explain the aggregate effect of all factors upon beef production but cannot isolate the effects of individual factors. This leads to structurally weak linkages between the beef component and the rest of the model and therefore, poor performance of the beef model relative to its strong R^2.

The fed beef model, as it is presently linked to the rest of the model, and specifically as it is linked to the beef and dairy cow inventory functions, generates five year, slightly explosive production cycles. The lag structure lengths in the fed beef and beef cow functions are 4 to 5 years in length and perhaps should be slightly longer. The dairy cow inventory lag lengths are generally six years in length which is believed to be reasonable in nature. However, unexpectedly short cycles of five years in length are generated for dairy cow numbers.

Non-Fed Beef

Non-fed beef consists of beef and dairy cow slaughter. Small changes in the culling rates of beef and dairy cows can create very large changes in the quantity of non-fed beef slaughter.

The number of beef and dairy cows in herd inventories are very significant factors in the non-fed beef slaughter function. The level of non-fed beef slaughter is not in turn placed in the cow inventory functions as a factor affecting cow numbers. This is a linkage option that has been considered but not yet tested.

The long-run expectations on prices for the products of beef and dairy cows (feeder calves and milk) as well as the fairly current non-fed beef price or opportunity cost of holding the cow in production influence cow slaughter rates.[1] The lag structures for beef and dairy cow prices are believed to reflect more than price expectation formation processes. They contain historical price pattern information which is directly linked to factors affecting the age structure of the cow herd. Since the physical and biological attributes of the cow-beef production activities are not clearly separated from the institutional and subjective factors, their separate effects cannot be determined.

The statistical significance of the non-fed beef price, fed beef price and milk price variables are weak, but their signs and lag structure are consistent with *a priori* expectations. The variable pasture condition exhibits a positive sign which may be questioned. It is argued here that a positive sign is to be expected. The dependent variable is total liveweight of slaughter and hence is affected by numbers slaughtered and weight. It is believed that pasture conditions are rarely a factor in affecting the number of cows slaughtered.

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[1]Note in regard to this statement that the output price lag structures (for feed beef and milk price) peak some two and four periods back respectively while the opportunity cost (non-fed beef price) peaks one period back. Feed beef price is used here as a proxy of beef cow output price, i.e. feeder calf price.

Hence, pasture conditions primarily proxy a feed availability factor affecting the weight of cows slaughtered. Hence, improved pasture conditions would result in heavier cows being slaughtered.

Silage production serves as a proxy for feeding cost. As is the case with fed beef, silage is assumed to be a non-market feed and hence the quantity available and not the price of silage is used.

Interest rate and wage rate variables indicated to be factors in non-feed beef production according to theoretical considerations were found to be insignificant. The effects of interest and wage rates is indirectly felt through their effect on cow herd levels.

Beef Cow Inventories

Beef cow numbers are specified to be a function of fed beef prices, non-fed beef prices, interest rates, silage available and beef cows on hand in year t-3. The lags found for these variables are typically four to five years in length which is slightly shorter than expected. The fed beef price variable is used as a proxy for feeder calf value which is the major direct product of the beef cow. The non-fed beef price proxies the value of the secondary product of the cow, low-grade meat, or opportunity cost of not slaughtering the cow. Silage available proxies the feed cost for the cow and enters as a quantity according to previous arguments. The interest variable proxies the capital cost of holding an investment in the cow and complimentary assets required to maintain a cow. The lagged beef cow inventory variable is reasoned to indicate the availability of heifers when the decision is made to change the flow of replacement heifers into the herd.

As was discussed in relation to the fed beef function, the beef cow inventory has trended upward over the last 20 years leading to statistical problems in estimating accurate structural parameters. This in turn leads to poor integrated performance of the function in the model relative to its goodness of fit. Specifically the beef cow function within the model tends to underestimate cow herd expansion rates.

Dairy Cow Inventory

Dairy cow numbers are specified to be a function of milk price, corn price, non-fed beef price and wage rates for non-farm workers. All variables included have highly significant statistical accuracy. The lag lengths found are five and six years respectively for milk and corn prices and shorter lags of four and three years respectively for non-feed beef prices and wages.

Wage rates appear as a significant factor in the dairy industry as opposed to having very little significance in other livestock activities. This was expected given the information observed in previous studies. However, the existence of an elasticity some four times larger than that for corn and milk was not expected. Wages actually serve as a dual proxy in that they represent an input cost as well as an opportunity cost to the farmer for his labor in non-farm activities. The latter influence of the wage proxy is likely the greater factor. High protein feed cost and interest rates were not found to be significant in the dairy cow inventory function.

Dairy Heifer Inventory

Dairy heifer inventory is estimated to be a function of milk price, corn price, soymeal price, wages and fed beef price. Relatively shorter lag structures (four years for milk and corn prices and two years for soymeal prices, wage and fed beef prices) were found for dairy heifers than dairy cows. Fed beef price is entered as a proxy for the opportunity cost of selling the heifer versus adding her to the dairy herd. The other variables proxy expectations about the profitability of milk production since the birth of the heifer.

The original intent was to use dairy heifer numbers as a factor in determining dairy cow numbers. However, this proved to not add any significance to the dairy cow number equation, hence this approach was dropped and dairy cow numbers are estimated independent of dairy heifer numbers. The dairy heifer inventory function is retained to provide input into feed demand relations.

Milk Production

Milk production is specified to be a function of milk price, corn price, non-fed beef price and wages. The statistical significance of each of these variables is strong and all signs obtained are as hypothesized. The lag structures selected are among the longest for any livestock product.

Wages appear in the milk production function as a strong variable as was the case in dairy cow and heifer inventory relations. In the milk production relation, however, the elasticity is of a mangitude similar to that for corn and milk prices and hence not so alarming as was the case in the dairy cow inventory relation. (See Table IV.1 in Chapter IV.)

Performance of the milk production relation in the integrated model is among the best performance for livestock relations. This is perhaps attributable to the strong significance of the structural parameters as well as the good fit.

Several alternative approaches to inject dairy cow numbers into the milk production estimate were tried. The first approach was to estimate a milk production per cow function and multiple cow numbers times yield per cow to obtain a production estimate. The approach suffered from an inability to obtain strong structural parameters for the milk yield function. Second, dairy cow numbers were injected into the milk production relation. This approach did not generate a better fit than the approach used. In addition the structural parameters of other variables were weakened by injecting the dairy cow numbers variable into the milk production relation.

Attempts to include soymeal price and interest rate in the milk supply function were rejected on the grounds of weak statistical significance. Silage availability and hay price variables were also rejected on the grounds of weak statistical properties.

Poultry Product Supply

Poultry supply response functions were estimated using geometric lag structures as opposed to polynomial lag structures. This lag structure was chosen based upon the belief that adjustment is relatively more rapid in the poultry industry than in other livestock categories. Attempts to fit polynomial lag models for poultry substantiated this belief. In addition, the parameters on the lagged dependent variable indicate that roughly 50 percent, 33 percent and 66 percent of the long-run adjustment in chicken meat, egg and turkey production occurs in one year.

All poultry supply functions include trend factors to proxy technological change in the industry. In the case of eggs and turkeys this variable is time, while in the case of chicken meat the variable is labor efficiency in broiler production. In each equation the technology change proxy is highly significant.

Own price and input prices for corn and soymeal are included in each equation. In the case of eggs these three prices are entered in the form of a gross margin, i.e., value per dozen eggs minus corn and soybean feed cost per dozen eggs. Weights for establishing corn and soybean ration cost are obtained from the feed consumption estimates. Own price and the gross margin variable enter with reasonable significance. However, corn and soymeal prices while having proper signs exhibit weak statistical significance.

It is felt that the poultry functions suffer heavily from the overall structuring of the livestock sector as a recursive model. Increased vertical integration in the poultry industry probably has reduced the flexibility of poultry producers to respond quickly to price signals. However, it is believed that considerable inter-year adjustment is still capable of being obtained in poultry production processes. Indeed inter-year responses in beef, pork and dairy cannot be ruled out either.

Table C-1.1 Pork Slaughter Function Parameters

	Independent Variable			
Period	Pork Price	Corn Price	Soymeal Price	Sows Farrowed Spring
t-1	163.96 (4.74)	-2258.15 (2.65)	-142.17 (0.34)	1.432[1)] (4.91)
t-2	166.32 (4.75)	-2772.06 (5.37)		
				R^2 = .935
t-3	86.69 (2.67)	-2156.90 (5.05)		
				D.W. = 1.819
t-4	4.71 (0.15)	-1027.82 (1.31)		Intercept = 12586.21
Average t-value	3.08	3.60	.34	4.91

[1)] Refers to Sows Farrowed in the Spring of the Current Crop Year, i.e. for Crop Year 1971 the Farrowing Figure would be sows farrowed in the spring of 1972.

Table C-1.2 Sow Farrowing (Fall) Function Parameters

Period	Pork Price	Corn Price	Soymeal Price	Fed Beef Price	Sows Farrowed Spring[1)]
	Independent Variables				
t-1	70.35 (2.52)	93.38 (.02)	-19.10 (.13)	-46.94 (1.37)	.7548 (5.18)
t-2	86.58 (2.39)	-503.95 (1.40)	-163.26 (1.37)	-37.69 (1.53)	
t-3	68.18 (1.98)	-1147.98 (4.66)	-297.87 (1.34)	-9.60 (.39)	
t-4	34.62 (1.18)	-1194.67 (2.35)	-288.32 (1.11)	R^2 = .93 D.W. = 3.49	
t-5	5.40 (.26)			Intercept = 5480.85	
Average t-value	1.67	2.06	.99	1.10	5.18

1) Sows farrowed the preceding spring which is in the same calendar year but a different crop year.

Table C-1.3 Sows Farrowing (Spring) Function Parameters

Period	Pork Price	Corn Price	Soymeal Price	Fed Beef Price	Wage	Sows Farrowed Fall[1)]
	Independent Variable					
t-1	147.27 (.41)	1060.28 (.84)	208.97 (.72)	-58.38 (.86)	-2984.66 (1.04)	.4104 (1.25)
t-2	203.91 (.98)	168.20 (.17)	-244.02 (.95)	-105.05 (2.15)		
t-3	193.71 (1.52)	-1254.02 (-1.35)	-801.48 (1.63)	-99.20 (2.02)		
t-4	140.46 (1.91)	-1784.16 (-1.48)	-905.97 (1.61)			
t-5	67.96 (2.10)					
Average t-value	2.40	.96	1.23	1.68	1.04	1.25

R^2 = .81

D.W. = 2.17

Intercept = 15541.17

[1)] Sows farrowed the preceding fall which is in the same crop year but a different calendar year.

Table C-1.4 Fed Beef Slaughter Function Parameters

	Independent Variable					
Period	Fed Beef Price	Corn Price	Soymean Price	Interest Rate	Silage Available	# Beef Cows + # Dairy Cows
t-1	391.10 (6.59)	-6243.53 (3.38)	-847.03 (1.07)	-680.20 (2.14)	.4548 (2.40)	1.652 (6.74)
t-2	420.11 (6.08)	-1371.88 (.84)	-731.86 (1.02)	-435.07 (1.77)		
t-3	253.57 (4.26)					
t-4	58.02 (1.34)					
Average t-value	4.57	2.11	1.04	1.96	2.40	6.74

$R^2 = .99$

D.W. = 2.57

Intercept = -69247.38

Table C-1.5 Non-Fed Beef (Cow) Slaughter Function Parameters

	Independent Variable						
Period	Non-Fed Beef Price	Fed Beef Price	Milk Price	Silage Available	Pasture Condition	#Milk Cows	#Beef Cows
t	0.00	0.00	0.00	-.49 (3.35)	150.82 (2.62)	1.67 (3.39)	1.23 (7.54)
t-1	163.54 (.42)	-42.80 (.12)	-51.12 (.20)				
t-2	150.74 (.40)	-59.18 (.18)	-196.74 (.77)				
t-3	62.57 (.23)	-45.97 (.19)	-350.64 (2.06)				
t-4			-426.62 (2.20)				
t-5			-338.47 (1.64)				
Average t-value	.36	.16	1.38	3.35	2.62	3.39	7.54

$R^2 = .96$

D.W. = 1.58

Intercept = -57228.24

Table C-1.6 Beef Cow Inventory (Jan. 1) Function Parameters

	Independent Variable				
Period	Fed Beef Price	Non Fed Beef Price	Interest Rate	Silage Available	Beef Cows
t-1	749.21 (2.84)	-740.29 (3.01)	-166.06 (.75)	.3399 (1.76)	
t-2	942.02 (3.03)	-863.11 (2.96)	-190.43 (1.01)	.5426 (3.89)	
t-3	770.96 (3.40)	-615.78 (2.81)	-131.76 (.96)	.5753 (3.29)	.4186 (2.74)
t-4	428.58 (4.43)	-245.64 (2.31)	-48.73 (.30)	.4054 (1.79)	
t-5	107.42 (2.91)				
Average t-value	3.32	2.78	.76	2.69	2.74

$R^2 = .99$

D.W. = 2.04

Intercept = -43689.46

Table C-1.7 Dairy Cow Inventory (Jan. 1) Function Parameters

	Independent Variable			
Period	Milk Price	Corn Price	Non Fed Beef Price	Wages
t-1	561.16 (4.67)	-809.48 (6.87)	-81.09 (7.51)	-7049.25 (4.84)
t-2	706.15 (4.70)	-1212.74 (7.59)	-108.30 (12.71)	-6933.66 (17.25)
t-3	578.73 (4.45)	-1291.61 (6.55)	-94.97 (7.59)	-3351.25 (2.18)
t-4	322.71 (3.35)	-1127.94 (4.55)	-54.43 (3.60)	R^2 = .99
t-5	81.87 (1.28)	-803.56 (2.98)		D.W. = 1.60
			Intercept = 60245.04	
t-6		-400.30 (1.95)		
Average t-value	3.69	5.08	7.85	8.09

Table C-1.8 Dairy Heifer Inventory (Jan. 1) Function Parameters

	Independent Variable				
Period	Milk Price	Corn Price	Soymeal Price	Wage	Fed Beef Price
t-1	-69.39 (2.06)	-158.53 (1.96)	-108.05 (3.22)	-1248.81 (2.39)	0.00
t-2	26.25 (0.77)	-391.56 (5.61)	-9.53 (0.27)	-1959.65 (3.52)	-20.21 (2.17)
t-3	156.58 (5.94)	-545.34 (7.71)		-1690.67 (3.25)	R^2 = .99
t-4	191.27 (8.30)	-466.08 (5.70)			D.W. = 2.75
					Intercept = 18553.61
Average t-value	4.27	5.25	1.75	3.05	2.17

Table C-1.9 Milk Production Function Parameters

Period	Independent Variables: Milk Price	Corn Price	Non Fed Beef Price	Wages
t-1	1562.50 (1.71)	-5933.81 (6.17)	-212.80 (2.46)	-23895.99 (1.98)
t-2	2570.35 (2.11)	-9090.44 (6.93)	-326.84 (5.22)	-17746.86 (5.18)
t-3	3043.84 (2.71)	-9949.44 (5.82)	-334.48 (3.07)	-2724.31 (0.21)
t-4	3003.26 (3.49)	-8990.35 (4.00)	-228.09 (1.70)	R^2 = .95
t-5	2468.89 (3.91)	-6692.71 (2.70)		D.W. = 2.78
			Intercept = 238169.62	
t-6	1461.04 (3.35)	-3536.09 (1.87)		
Average t-value	2.88	4.58	3.11	2.46

Table C-1.10 Poultry Product Supply Response Function Parameters

Quantity Supplied	Independent Variables										
	Broiler Price t-1	Gross Margin for Eggs t-1	Turkey Price t-1	Corn Price t-1	Soymeal Price t-1	Broiler Labor Efficiency	Time[1]	Q_{t-1}	Intercept	R^2	D.W.
Chicken Meat	107.94 (3.57)	-	-	-149.94 (.23)	-326.54 (1.75)	-3440.22 (3.82)	-	.51 (2.99)	5944.94 (3.09)	.99	2.02
Eggs	-	11.66 (1.91)	-	-	-	-	16.76 (3.22)	.67 (3.18)	544.11 (.23)	.76	1.84
Turkeys	-	-	24.71 (3.19)	-407.02 (1.51)	-2.21 (.04)	-	51.86 (3.26)	.33 (1.21)	-2431.08 (7.65)	.95	1.65

[1] 1950 = 50

APPENDIX C-2

CROP SECTOR PLANTING, HARVESTING AND YIELD FUNCTIONS

Within the crop sector of the model three types of functions are specified, acreage planted, acreage harvested and a yield function. Acreage harvested estimates are multiplied by estimated yields to obtain estimates of total production.

Initial work for the crop sector of the model was begun by John McKeon as a part of his Ph.D. dissertation.[1] His dissertation dealt primarily with crop planting responses and gave special consideration to measuring the impact of government programs on planting response in the '50's, '60's and early '70's. The acreage response functions used in the model are those developed by McKeon in his dissertation. Yield and harvested acres functions were subsequently added to complete the crop sector.

A key factor in McKeon's crop planting functions is the method used to quantify the influence of government policy. McKeon specifies two variables in this regard, an "effective support price" and an "effective diversion payment" variable. The variables are defined as follows:

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[1]John McKeon, "Farm Commodity Programs: Their Effects on Plantings of Feed Grains and Soybeans," unpublished Ph.D. dissertation, Michigan State University, 1974.

$PV1 = rPA$

$PV2 = wPR$

where

PV1 - Effective support rate

r - An adjustment factor reflecting planting restrictions

PA - Announced support price

PV2 - Effective diversion payment

w - Proportion of acreage eligible for diversion

PR - Payment rate for diversion

These variables are calculated for each crop which was influenced by government support and acreage restriction policies.

These two variables have been quite satisfactory in describing acreage planted responses during the late 50's, 60's and early 70's. However, the adoption of the target price concept and the removal of crop specific acreage restrictions has created a policy situation the variables are not ideally suited to describe.

The U.S. feedgrain and foodgrain crop sector has essentially shifted since 1972 from a controlled, surplus component of the agricultural sector to a free market, non-surplus component of the agricultural sector. Because of this new situation, new assumptions and consequent restructuring of the model are necessary to realistically simulate the crop sector beyond 1972. This presents a problem in regard to econometrically obtaining parameters since there are only a limited number of observations of acreage response in this new environment. Parameters may best be obtained by non-econometric methods.

The problem of restructuring the crop sector of the model to realistically represent the period from 1972 to the present is currently in process. Until such a restructuring is accomplished, projections beyond 1972 and policy analysis dealing with aspects of crop response in this new environment are hampered.

McKeon's acreage response functions (presented in Table C-2.1A) for the most part follow the theoretical guidelines given in Chapter III. Own policy variables and substitute crop policy generally enter the function as well as own market price and substitute crop market prices lagged one period. Market prices are lagged one period to form a simple price expectation model. With the exception of soybeans, no acreage planted function contains a lagged dependent variable, hence complete adjustment with a single period is assumed. Futher discussion of the acreage planted functions and supporting theory can be found in McKeon's thesis.

The acreage harvested functions (presented in Table C-2.1B) are derived from the acreage planted functions. Acreage planted is the major factor determining acreage harvested in every relation. Other factors, considered include weather, technological improvements, expected crop prices, livestock herd compositions and a diminishing marginal return factor.

Pasture condition is used to proxy weather conditions from planting to harvest. This variable is reported by the USDA by state and by month. A national calendar year average was calculated from the monthly state data. It would appear that the monthly and state specific reports could be made into a better proxy by selecting

Table C-2.1A Acres of Crops Planted Functions

Commodity \ Independent Variable[1]	PV1C	PV2C	PC_{t-1}	PSB_{t-1}	PW_t	$YLDC_{t-1}$	$YLDSB_{t-1}$	$APSB_{t-1}$	Constant	R^2	Durbin Watson	Degrees of Freedom
Corn	10063.8 (3.03)	-71943.1 (7.98)	2196.1 (.48)	-1434.4 (.77)	-6605.8 (2.87)	108.2 (1.54)			76653.1 (9.94)	.46	2.25	22
Soybeans	-10589.2 (4.41)	-12587.1 (1.88)		7810.1 (5.73)	-1524.9 (.67)		352.3 (1.35)	.70 (5.37)	-2774.0 (.50)	.99		22
	PV2SH	PFERT	PSH_{t-1}	PCT_{t-1}	PW_{t-1}	PV5873						
Sorghum	-13284.6 (4.65)	-62.2 (.59)	11619.4 (2.46)	-137.3 (1.30)	-1928.1 (.96)	-3423.5 (2.78)			26164.6 (3.72)	.88		17
	PV1B	PV2B	PB_{t-1}	PO_{t-1}	APW	PCAP	DV6573					
Barley	1572.7 (.57)	-14479.6 (2.67)	5747.3 (1.05)	-13097.9 (1.27)	-.25 (4.83)	-133.5 (.54)	-2878.5 (3.32)		31324.3 (9.19)	.89	1.40	22
	PV1O	PO_{t-1}	APW	TIME	DV6873							
Oats	491.5 (.04)	7739.2 (.50)	-.27 (2.48)	-1820.9 (10.78)	7204.1 (3.52)				6460.9 (7.24)	.94	.91	22
	PV1W	PV2W	PW_{t-1}	PC_{t-1}	PSH_{t-1}	WEATH						
Wheat	26526.9 (5.16)	-5386.8 (1.66)	16072.2 (4.06)	-2497.5 (.23)	-12948.7 (.70)	449.9 (1.69)			6045.5 (.67)	.87	2.26	22
	PV1CT	PV2CT	PCT_{t-1}	PCAP	PFERT	PSB_{t-1}						
Cotton	619.2 (6.38)	3435.3 (2.02)	577.6 (4.85)	-308.7 (.95)	-521.9 (3.54)	6736.4 (4.69)			21039.6 (1.65)	.95		22

[1]See variable description list at the end of Section C of this table for definitions.

Table C-2.1B Acres of Crops Harvested Functions

Commodity / Independent Variables[1]							Constant	R^2	Durbin Watson	Degrees of Freedom
	PV1C	APC	LIVCOMP	TIME	TIME SQUARED		Constant			
Corn (Grain)	997.3 (.40)	.886 (12.80)	-8034.1 (.77)	231.80 (.13)	.757 (.05)			.98	2.26	22
Corn (Silage)	-727.4 (.98)	.024 (.66)	1087.3 (.71)					.77	1.65	19
	APSH	DELTA APSH	LIVCOMP	DV70	TIME	TIME SQ				
Sorghum (Grain)	.656 (5.56)		-22535.6 (1.46)		25.36 (.01)	7.24 (.30)		.81	1.46	19
Sorghum (Silage)					622.66 (7.51)	-5.28 (7.70)		.94	2.21	19
	APO	TIME	TIMESQ							
Oats	.739 (10.10)	-2688.48 (2.76)	19.82 (2.48)				91644.4 (3.00)	.99	2.08	19
	APB	TIME	TIMESQ							
Barley	.913 (17.42)	-896.27 (1.68)	7.54 (1.69)				26093.8 (1.69)	.98	1.22	19
	APW	APSH	$WHTP_{t-1}$	DELTA APW	TIME	PASTCD				
Wheat[2]	.290 (3.00)	.321 (1.63)	-591.4 (.12)	-.012 (.13)	-116.2 (.24)	-357.1 (2.45)	21265.6 (.40)	.62	1.83	20
	DELTA APSB	TIME	TIMESQ							
Soybeans[3]	.024 (1.08)	-834.07 (7.04)	6.40 (6.55)				28018.4 (7.86)	.92	2.27	19
	APCT	DELTA APCT	PViCT	$CUTP_{t-1}$	PASTCD	TIME				
Cotton	.837 (24.59)	-.085 (2.83)	56.18 (2.51)	125.66 (4.07)	38.00 (1.30)	196.48 (3.42)	-19274.7 (3.08)	.98	2.14	20

[1] See variable description list on the page following Section C of this table for definitions.

[2] Unharvested Acres as opposed to harvested acres are estimated.

Table C-2.1C Crop Yield Functions

Commodity \ Independent Variables[1]	PV1C	PV2C	PFERT	TIME	PASTCD	DV70	Constant	R^2	Durbin Watson	Degrees of Freedom
Corn (Grain)	7.63	23.80	-.15	2.62	.23	-14.18	-112.22	.98	3.05	20
	(1.84)	(2.03)	(.60)	(3.30)	(.88)	(4.58)	(1.19)			
Corn (Silage)	YLDC	TIME								
	.096	.012					3.18	.94	1.48	20
	(3.54)	(.18)					(1.16)			
Sorghum (Grain)	PV2SH	DELTA APSH	PASTCD	TIME	DV70					
	16.19	-.001	.37	1.96	8.46		-113.82	.95	1.40	20
	(1.80)	(1.06)	(1.25)	(8.30)	(2.23)		(4.11)			
Sorghum (Silage)	YLDSH	TIME								
	.201	-.141					9.75	.94	1.46	20
	(7.15)	(2.23)					(3.42)			
Oats	PNO_{t-1}	PFERT	TIME	AHO/APO						
	6.87	-.45	1.13	15.25			57.76	.88	.91	22
	(.47)	(2.45)	(6.70	(.63)			(2.10)			
Barley	PB_{t-1}	AHB	PFERT	PCAP	TIME					
	10.48	28.71	-.50	-.75	1.14		37.93	.95	2.18	22
	(2.71)	(1.71)	(4.75)	(1.71)	(9.74)		(2.47)			
Wheat	$WHIP_{t-1}$	PV2W	PFERT	PASTCD	TIME	DV66,67				
	1.50	1.52	-.02	.21	.89	-2.21	-47.68	.93	2.53	20
	(.25)	(1.83)	(.03)	(1.75)	(5.12)	(2.71)	(1.01)			
Soybean	PFERT	PASTCD	TIME							
	-.062	.176	.273				-.44	.89	1.71	20
	(.85)	(2.12)	(1.49)				(.02)			
Cotton	PCT_{t-1}	PV2CT	PFERT	AHCT/APCT	TIME					
	1.73	93.58	-.56	1515.19	8.21		-1103.39	.78		22
	(.47)	(2.79)	(.26)	(3.55)	(3.13)		(2.57)			

[1] See variable description list on the following page for definitions.

Table B-2.1 (Continued) Variable Codes

Combination of the following codes are used to describe variables.

Crop Categories

C - Corn
O - Oats
B - Barley
SH - Sorghum
W - Wheat
SB - Soybeans
CT - Cotton

Price

PV1 - Effective support price
PV2 - Effective diversion payment
P - Price received by farmers

Others

YLD - Yield
AP - Acres planted
AH - Acres harvested
PCAP - Proxy for capital cost (interest rate)
PFERT - Fertilizer price
TIME - A linear trend value i.e. 50,...,71
DELTA - Value in period t minus the value in t-1
WEATH - Weather variable (rainfall at planting time)
PASTCD - Weather variable (pasture condition)
DV - Dummy variable followed by a subscript for the years in which the value is one, i.e. DV5873 equals one from 1958 to 1973 while DV70 equals one only in 1970.
LIVCOMP - Livestock herd composition (defined in the discussion).

certain states and key months for each crop and proceeding on this basis to calculate an aggregate weather variable for each crop. The pasture condition variable in its present crude form enters into several of the acres harvested and yield functions.

Time as a proxy for technology which improves harvesting efficiency and thus reduces unharvested acreage enters all of the acres harvested functions. A price expectation variable, either lagged market price or the effective support price enters a number of the acres harvested functions. Lastly, the first difference of acres planted enters in a number of acres planted equations. The rationale for this variable is that when large expansions in acreage occur, diminishing marginal productivity will be encountered and a larger than usual number of acres will be left unharvested.

In the case of corn and sorghums, acres harvested must be divided into those harvested for grain and for silage. A "livestock herd composition" variable is used in an attempt to assist in this division. The herd composition variable consists of a ratio of the previous year's consumption of feedgrain by roughage intensive livestock (fed and non-fed beef, dairy cows and dairy heifers) to the previous year's consumption of feed grains by non-roughage intensive categories of livestock (pork, chickens, eggs and turkey). It is hypothesized that a large population of roughage intensive animals in the previous year relative to non-roughage intensive animals will lead to increased silage production. Indeed the signs of the livestock composition variable substantiate this hypothesis, but with weak significance levels.

With regard to the yield functions, the following variables are included in various equations: a price expectation proxy (either PV1 or lagged market price); proxies of diminishing marginal physical product effects (proxied either by PV2 signifying the acreage restriction level or by delta acres planted); fertilizer prices; the ratio of acres harvested to acres planted, also a weather effect proxy; time, generally a highly significant proxy of yield improving technology; and the price of capital and input cost. Corn silage yields and sorghum silage yield are estimated as functions of corn and sorghum grain yields.

It should be noted that at present the crop subsector is not nearly as complete in terms of commodity coverage as the livestock subsector. Tobacco, fruits, vegetables and various speciality crops have been ignored. In addition, the production of roughage has largely been ignored with the exception of consideration given to silage. It would appear that given the recent magnitude of roughage substitution for grain, that consideration of pasture, hay and forage production is a vitally needed additional crop category and crop-livestock interfacing link.

APPENDIX C-3

DERIVED DEMAND FOR FEEDS

Derived demand for feed by livestock is divided into three categories; demand for feedgrains (which consists of corn, oats, barley and grain sorghum aggregated by weight), soybean meal wheat. Total demand for feedgrains and soybean meal is determined in a two-step process. In the first step, demand for feedgrains and all high protein feeds is estimated for each of eight livestock categories. (See Table C-3.1 for categories). These categories comprise well over 90 percent of a typical year's demand for livestock feed. The eight estimates are then summed and placed in a function which estimates total livestock demand for feedgrains and soybean meal. Note that in the case of soybean meal a change of definition occurs and will act as a bridging from a subset of demand to total demand.[1]

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[1]The total feedgrain demand and soybean meal demand functions are as follows:

$$F.G.^{D} = \underset{(3.24)}{632004.709} + \underset{(6.87)}{1.330}\ \text{Categories}$$

$$-\underset{(2.74)}{31999.906}\ \text{Corn Price} + \underset{(1.02)}{5396.148}\ \text{Soybean Price}$$

$$-\underset{(3.04)}{153941.808}\ \text{Log Time}$$

$R^2 = .96$ Durbin Watson = 1.85 Degrees of Freedom = 19

$$\text{Soymeal}^{D} = 773656.233 + 1.088\ \text{Categories}$$

$$-863.456\ \text{Soymeal Price} - 2589.877\ \text{Time} + 20.747\ \text{Time Square}$$

$R^2 = .99$ Durbin Watson = 1.92 Degrees of Freedom = 19

Demand for wheat for livestock feed is estimated in a single equation. The price of corn, as a substitute feed, the price of wheat, the quantity of grain fed as a proxy for grain consuming animal units present, private wheat stocks at the end of the crop year as a proxy for a "within year" timing factor in wheat feeding and a lagged wheat fed variable are used as variables in the equation:

$$\begin{aligned} \text{Wheat Fed} = & \underset{(.61)}{-3146.151} + \underset{(3.92)}{6446.029}\ \text{Corn Price} \\ & \underset{(-4.09)}{-4231.947}\ \text{Wheat Price} + \underset{(.98)}{.030}\ \text{Grain Fed} \\ & \underset{(1.41)}{+.040}\ \text{Wheat Stock} + \underset{(1.20)}{.217}\ \text{Wheat Fed}_{t-1} \end{aligned}$$

The wheat stock variable and lagged wheat fed variable warrant further discussion. With regard to wheat stocks it is argued that much of the wheat feeding that is done comes during the latter part of the year when corn supplies run short. Large wheat stocks in private hands at this time would be conducive to wheat feeding. Another timing factor in wheat feeding is the existence of low quality or specifically unstorable wheat because of moisture content, etc., at wheat harvest time. This factor is not considered.

With regard to the lagged wheat fed term the habit persistence argument is advanced. This argument will be developed in detail presently with respect to feedgrains and protein feeds.

The demand functions for feedgrain and for high protein feeds are listed in Tables C-3.1 and C-3.2 respectively. Current period corn price (which proxies all feedgrain prices) and soymeal price (which proxies all high protein feed prices) enter nearly all functions. The exceptions being milk production where no significant response to

Table C-3.1 Feedgrain Consumption Functions by Livestock Category

Category	Corn Price	Soymeal Price	Silage Available	Output Price	Quantity Produced	Number of Breeding Stock	Interest Rate	Wage Rate	Lagged Dependent Variable	Other[a] #1	Other[a] #2	Constant	R^2	Durbin Watson Test
						Independent Variable								
Pork	-8344.258 (2.08)	639.963 (.59)			1.005 (2.51)	1.221[1] (.73)	-945.675 (1.97)	-9539.507 (2.19)	.426 (1.88)	644.230[2] (2.54)		28328.042 (1.81)	.89	2.73
Fed Beef	-3798.120 (.77)	1410.774 (.95)	-.157 (.38)	253.123 (2.08)	.006 (.02)	.430[3] (1.14)			.909 (9.86)			-13857.911 (1.66)	.99	2.31
Non Fed Beef	-2591.723 (2.34)	539.194 (1.71)	-.160 (.90)	56.777 (1.02)		.170 (1.77)			.518 (3.77)	-48.853[4] (1.56)		4314.237 (1.36)	.98	2.50
Milk	-2345.464 (1.41)	92.986 (.20)		2293.114 (1.67)	.238 (2.12)				.777 (5.42)			-33526.101 (1.67)	.93	1.90
Dairy Heifers	-320.467 (.93)	157.464 (1.28)				.277 (2.40)			.522 (2.40)			-860.086 (1.44)	.88	2.08
Chicken	-29.405 (.03)	-46.882 (.25)		134.250 (2.11)	.821 (1.72)					1834.670[5] (2.78)	-13.155[6] (2.37)	63859.653 (2.90)	.97	1.94
Turkey	-1970.632 (1.85)	-56.224 (.21)		79.020 (1.28)					.935 (2.47)			1039.51 (.88)	.83	2.27
Eggs	-232.297 (.14)	686.994 (1.85)		103.117 (2.00)	5.634 (2.15)				.191 (.66)			-26133.503 (1.94)	.81	2.44

[a] See listing below for definition of these variables.

[1] Sows farrowed in the fall; [2] Gross Margin on Pork - see data definitions in Appendix I; [3] Number of Beef cows t-1;
[4] Pasture Conditions; [5] Time; [6] Time Square.

Table C-3.2 High Protein Feed Consumption Functions by Livestock Category

	Independent Variable														
Category	Corn Price	Soymeal Price	Silage Available	Output Price	Quantity Produced	Number of Breeding Stock	Interest Rate	Wage Rate	Lagged Dependent Variable	Other[a]	Other[a]	Constant	R^2	Durbin Watson	Degrees of Freedom
Pork	1555.178 (.22)	-453.464 (2.59)		9.300 (2.43)	.070 (.66)	1.227[1] (3.37)				156.502[2] (3.22)		-6018.369 (2.35)	.83	1.87	16
Fed Beef	122.310 (.30)	-64.473 (.43)		10.205 (.70)	.070 (1.47)	-.052[3] (1.57)			.786 (3.15)			286.072 (.40)	.85	1.96	20
Non Fed Beef	140.691 (.59)	-219.112 (2.69)		28.922 (2.59)		.011 (1.24)			.178 (.71)	-23.495[4] (2.00)		3302.657 (2.41)	.77	2.46	20
Milk				.016 (1.01)		-.032 (1.80)			.617 (3.31)			-361.308 (.19)	.66	1.62	19
Dairy Heifers	-186.019 (1.35)	-29.244 (.73)				.060 (1.44)			.626 (3.15)	-1.533[4] (.30)		308.879 (.60)	.74	2.35	18
Chicken	-203.852 (.38)	-10.076 (.10)		72.488 (1.84)	.430 (1.45)					1690.537[5] (4.14)	-13.120[6] (3.81)	-54796.783 (4.02)	.96	1.11	20
Turkey		-21.691 (.50)			.334 (1.52)				.365 (.99)			281.471 (.46)	.82	2.49	20
Eggs	-340.827 (1.37)	-230.592 (2.56)		24.210 (1.44)						-423.123[5] (2.18)	3.958[6] (2.65)	-5322.517 (2.32)	.94	1.84	20

[a]See listing below for definition of these variables.

[1]Number of Sows Farrowed in the Fall; [2]Gross margin on pork; [3]Number of beef cows t-1; [4]Pasture condition; [5]Time; [6]Time Squared.

feed prices or proper signs on feed prices could be obtained, and turkeys where corn price was not included because it generated sign problems on other variables in the function. Significance of the corn and soymeal price coefficients are not as strong as desired in all cases. In the case of poultry products, feedgrains and high protein feeds are in general indicated to be compliments according to the signs of the corn and soymeal price. This would appear to be an acceptable implication for these activities. High protein feeds are also indicated to be a compliment to feedgrains in the case of dairy heifers. Silage available enters as a weakly significant substitute for feedgrains in the cases of fed and non-fed beef. Silage did not yield the expected sign in the milk category and hence was dropped.

According to theoretical specifications output prices should enter derived demand functions, output price did so with an expected sign and with uniformly better significance than corn or soymeal price. Quantity produced and/or the number of breeding stock present at the first of the year generally entered all equations with reasonable significance. A notable exception is feed beef. Theory suggests that such quantity variables should enter as proxies for fixed asset levels. Interest and wage rates which proxy capital and labor cost in general were not significant in the derived feed demand relations.

Lagged dependent variables, particularly in the case of beef, dairy and pork are included and are significant. The rationale for including such a variable is based upon partial adjustment or habit persistence models. Producers tend to establish a given feeding rate and ration mix which is "practical" under a range of conditions.

They do not significantly change this feeding practice unless input and output market conditions significantly change. Indeed the lagged dependent variables in fed beef and milk production feed demand relations indicate that the adjustment is very slow.[2] Faster adjustment appears to be indicated in pork, non-fed beef and poultry. The non-inclusion of a lagged dependent variable (as is the case for chicken, feedgrain and protein demand and pork and egg protein demand) implies complete adjustment in a year to price change.

Habit persistence in beef and dairy rations may be particularly noticeable due to the fixed asset compliments required for in their feeding systems. Forage intensive feeding systems in beef and dairy production require specialized storage systems and generally are based on self-produced sources of feed. Hence, in general one would expect greater habit persistence in roughage intensive livestock categories using self-produced feedgrains and a limited amount of purchased high protein feed. Indeed this appears to be the pattern of the lagged dependent variable coefficients in the livestock categories listed. An exception is the coefficient for lagged turkey feedgrain consumption which, according to the preceding general rule, should be considerably lower.

Time as a proxy for improved feeding technology and efficiency was found to be a necessary variable to include in chicken and egg

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[2]The larger the coefficient upon the lagged dependent variable the slower is the adjustment rate implied. The per period rate of adjustment in percentage terms toward desired total adjustment is calculated as $1 - B$ where B is the coefficient on the lagged dependent variable.

categories of feed demand (with the exception of egg feedgrain demand). Pasture conditions enter into non-fed beef feedgrain and protein feed demand. Significant substitution of grass for grains when pasture conditions are favorable is indicated. Pasture condition also enters the dairy heifer protein feed demand relation.

In summary, the general significance of the parameters in the derived feed demand equations are somewhat weak. In a number of cases deviation from the theoretical base was required and statistical properties as opposed to theory played a major role in selection of variables to be retained in the function. Some multicolinearity problems arise with the simultaneous inclusion of output price, quantity produced and a lagged dependent variable.

An alternative method to estimating feed demand would be to directly estimate feedgrain demand and high protein feed demand in one equation and not consider separate categories of livestock demand. Such an approach has been used elsewhere in other models and in general involves aggregating livestock population or slaughter figures by some form of feed equivalent or value weighting scheme. Such an approach may give greater aggregate consistency but lacks structural detail as to the causes of shifts in demand for grains and protein feeds. This approach would appear to assume that output prices (depending on the weighting procedure used) have no role in influencing feed demand. This appears inconsistent with findings here.

A second alternative approach is to use fixed feeding rates. This allows no economic adjustment of rations as does the approach taken here. The NASS model does consider feeding rates in the solution process as a constraint upon feed demand relations. Feeding rates per livestock unit implied by the feed demand functions and livestock supply estimates are not allowed to exceed certain feasible upper or lower bounds. Therefore, the feed demand functions are constrained to appear roughly as follows:

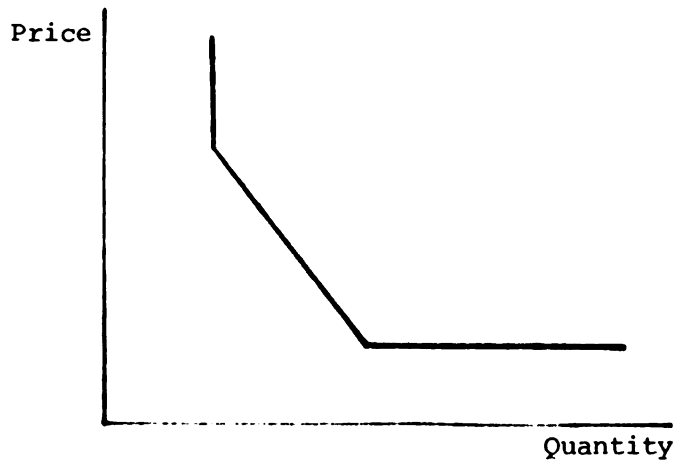

Figure C-3.1. Constrained Derived Feed Demand

All of the adjustment or constraint imposition for inconsistency between feed consumption and livestock production is forced into the feed demand equation. An interesting question is whether or not part of this adjustment should be imposed upon production levels.

The feeding rate constraint factor is called upon relatively few times in the historical tracking runs. Imposition of a lag structure for livestock production which allows adjustment to current period feed prices may lead to more accurate implied rates of feed consumption, and less need for such a constraint routine.

The specification of current period production reaction to feed prices would make feed consumption and livestock production simultaneously determined. This, in turn, would affect the fixed asset argument in the derived demand theory previously discussed in Chapter III. A fixed asset effect would still definitely remain in certain livestock categories but the proxy of such conditions might have to be altered from that used here, i.e., feeder calf population may be a better proxy in the case of beef.

Individual livestock category feed consumption data is obtained from the USDA publication Livestock-Feed Relationships, National and State. The nature of this data is somewhat suspect. Feed allocations are made to each category on the basis of feed equivalent animal units. This equivalence index is derived through physical knowledge of growth nutrient requirements. Limited surveys of producers of various types of animals are made each year to determine if unique conditions exist causing the base animal equivalent indices to be different for the given year. Lastly, at the aggregate level, livestock feed utilization estimates are forced to enter a balance sheet of grain utilization in a consistent manner. Hence, the process of determining feed consumption by animal category is somewhat crude in nature and may lead to inaccuracies in the data. These inaccuracies could account for some of the poor statistical properties of individual feedgrain and protein feed demand functions.

APPENDIX C-4

DIRECT DEMAND FOR HUMAN CONSUMPTION

Direct demand functions contained in the model are of two specification types, price dependent and quantity dependent. The price dependent specification occurs in the case of a recursive single source of demand market structure while the quantity dependent form appears elsewhere. In the NASS model this results in direct demand relations for livestock being specified as price dependent and all other direct demand relations as quantity dependent.

All direct demand functions are specified at the farm level. Farm level prices, and liveweight quantities are generally used. The exception being chicken and turkey meat quantity which are on a ready-to-cook weight basis.

In the case of livestock product demand, (specified as price dependent) own quantity, substitute quantity and income effects are considered. In the case of direct demand for grain products (which is quantity dependent) only own price and income effects are considered. No substitution between meat products and grain is considered in any of the direct demand relations.

Table C-4.1 presents the livestock product demand relations while Table C-4.2 presents the direct demand quantity dependent function in the model.

In observing Table C-4.1 identical parameters and t-values occur in numerous instances. This occurs because the variables with the identical parameters were summed to form one aggregate variable. One case of complimentarity is observed in the relations. Milk and eggs are indicated to be compliments in the milk price function. The reverse does not hold in the egg price function. The complimentarity of milk and eggs seems plausible at the farm level due to the joint use of these two products in producing many processed foods.

In general the signficance of individual parameters appears strong, particularly the income parameters. The Durbin-Watson test values indicate problems with positive serial correlation in several instances. Serial correlation adjustment procedures have not been implimented for any of the functions.

Table C-4.1 Price Dependent Livestock Product Demand Functions

Dependent Deflated Price	Independent Variable: Pork[1]	Fed[1] Beef	Non-Fed[1] Beef	Beef[1] Imports	Milk[1]	Chicken[1]	Turkey[1]	Eggs[1]	Disposable[1] Income Deflated	Constant	R^2	Durbin Watson	Degrees of Freedom
Pork	-.403 (6.53)	-.275 (4.42)				-.203 (.98)	-.203 (.98)		.015 (3.47)	67.602 (8.41)	.81	1.14	20
Fed Beef	-.009 (.21)	-.366 (8.59)	-.344 (6.69)	-.344 (6.69)			-.144 (.27)		.021 (8.31)	38.063 (5.81)	.90	1.93	20
Non-Fed Beef		-.309 (9.50)	-.353 (8.10)	-.353 (8.1)					.020 (8.66)	24.013 (8.53)	.87	1.77	20
Milk[2]	-4.630 (.58)	-4.630 (.58)	-4.630 (.58)	-4.630 (.58)	-4.677 (1.13)	-12.459 (.32)	-12.459 (.32)	246.171 (3.60)	.888 (.65)	302.276 (.06)	.65	1.23	20
Chicken		-.226 (2.41)				-1.060 (2.26)	-1.717 (1.35)		.019 (2.66)	46.229 (8.08)	.91	1.16	20
Turkey		-.252 (2.30)				-.709 (1.30)	-2.660 (1.79)		.017 (2.02)	57.640 (8.64)	.90	1.08	20
Eggs[3]	-.001 (.02)	-.001 (.02)	-.001 (.02)	-.001 (.02)		-.001 (.02)	-.001 (.02)	-4.182 (2.82)	.060 (3.85)	403.616	.91	2.36	20

[1] All quantities are per capita.

[2] All decimal points in the parameters have been shifted three positions to the right.

[3] The relation also includes a time variable with a parameter of -6.167.

Table C-4.2 Quantity Dependent Direct Demand Functions

Quantity Demanded	Wheat Price	Corn Price	Non-Fed Beef Price	Fed Beef Price	Non-Fed Beef Slaughter	Disposable GNP	Per Capita Disposable Income	DV1964[1]	Constant	R^2	Durbin Watson	Degrees of Freedom
	Independent Variable											
Wheat	-560.668 (2.72)					.001 (1.03)			15630.723 (18.21)	.92	1.52	19
Feed Grains		-1155.108 (2.79)					4.581 (13.44)		2861.532 (2.23)	.98	1.51	19
Beef Imports (per Capita)			-1.520 (1.39)	1.000 (1.06)	-.403 (5.02)		.015 (3.62)	-2.610 (.96)	-10.568	.81	1.53	6

[1]Zero before 1964 and one after during and after 1964.

APPENDIX C-5

PUBLIC AND PRIVATE STOCK DEMANDS

Functions specified for public (government) and private feed-grain and wheat stock demands deviate from theory presented in Chapter III more severely than any other functions in the model. In addition the integrated model tracking ability of the stock functions is in need of improvement.

Initial stock function specifications attempted to treat stock as a residual demand or "missing value" in this supply demand identity. Hence initial specifications were of a nature such that they included all quantities in the supply-demand identity and price. This approach is still strongly reflected in the feedgrain and soy-bean stock functions and private sector wheat stock function.

The government wheat stock demand function is more in keeping with the theory of Chapter III where the difference between market price and support price proxies the factors considered to create de-sired government stock demand. The lagged dependent variable then converts the function into a stock adjustment model. Two adjustment rates are allowed by placing a slope dummy on the lagged dependent variable. The dummy causes the higher parameter or implied adjust-ment rate to be used prior to 1962 when government wheat stocks were growing and the lower or implied adjustment rate to be used after 1962 when government wheat stocks were falling.

A distinct nonlinear relation is felt to exist between prices and government stock levels. To cope with this belief in a linear model an iterative solution adjustment algorithm was developed for each government stock model. Whenever government stocks fall below a certain minimum level, which is specified by the user as an exogenous variable, the solution algorithm injects a positive intercept shift upon the government stock function and resolves the model. Iterative adjustments are made to the government stock model until the minimum constraint is satisfied or a set number of adjustments attempting to satisfy the constraint have been completed.

Government stock purchases are also forced to increase by use of intercept shifting factors if support prices are not maintained for wheat, corn or soybeans. Again, iterative adjustments to government stock models are made until the predicted market price is just below the support price, or a specified number of adjustments have been attempted. The level at which market prices may be allowed to drop below the support price before the solution algorithm attempts to raise the market price by increasing government purchases is also an exogenous variable that can be specified by the user.

Hence the iteratively constrained government stock demand equations graphically appear as follows:

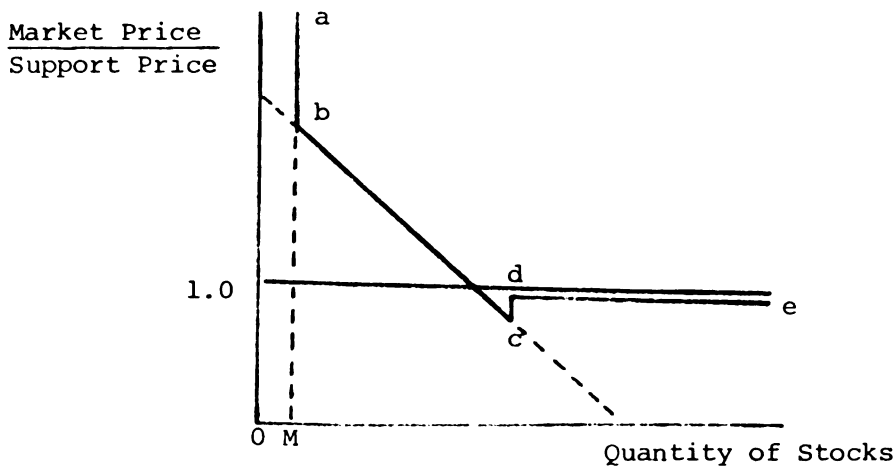

Figure C-1.1 Constrained Government Stock Demand

Where abcde is the constrainted government stock demand function, OM is the minimum allowable government stock level and dc is the tolerated amount by which market prices can drop below support (expressed in ratio terms) before the demand curve is iteratively adjusted upward. bc if linearly extended as indicated would represent the basic government stock demand function.

Table C-5.1 Public and Private Stock Demand Functions

Dependent Variable \ Independent Variable	Corn Price	PV1 Corn	Total Feedgrain Exports	Livestock Feedgrain Consumption	Feedgrain Prod.	Lagged Gov. Stocks	Constant	R^2	Durbin Watson	Degrees of Freedom
Government Feed-grain Stocks (1,000 tons)	-9104.1 (-3.05)	3061.2 (2.26)	-.34 (-5.90)	-.15 (-5.01)	.06 (1.58)	-.69 (11.52)	26664.0 (3.05	.99	2.57	19
	Corn Price	Delta Feedgrain Utiliza-tion	Delta[1] Feedgrain Production	Lagged Feedgrain Stocks						
Private Feedgrain Stocks (1,000 tons)	-16198.1 (-3.90)	-.26 (-1.71)	.31 (3.08)	.62 (7.66)			30138.4 (3.33)	.94	1.36	19
	Wheat Price Support Price Difference		Lagged Gov. Stk. (growth)	Lagged Gov. Stk (contraction)						
Government Wheat Stocks (1,000 tons)	-23778.8 (2.42)		.79 (7.84)	.67 (5.37)			6390.1 (2.51)	.83	1.68	19
	Gov. Stk. of Wheat	Wheat Price	Delta[1] Human Wheat Demand	Delta[1] Exports of Wheat	Delta[1] Wheat Acres Planted	Lagged Private Stocks				
Private Wheat Stocks (1,000 tons)	-.08 (2.33)	-1984.8 (3.76)	-1.30 (.82	-.06 (.94)	.05 (1.09)	.15 (.85)	8595.5 (4.92)	.82	1.87	19
	PV1 Soybeans	Soybean Price	Delta[1] Livestock Soymeat Consumption	Delta[1] Soybean Exports	Delta[1] Soybean Production	Lagged Soybean Stocks				
Soybean Stocks (1,000 tons)	5148.3 (4.54)	-4133.4 (4.02)	-.78 (2.08)	-.50 (1.87)	.79 (5.21)	1.17 (9.08)	-2082.9 (1.30)	.92	1.55	19

[1]Delta refers to the change between the current period and previous period.

APPENDIX C-6

MISCELLANEOUS DOMESTIC FUNCTIONS

In addition to the equations discussed in the preceding sections of this appendix a number of other domestic functions exist in the model. Specifically these equations are seed demand functions, feedgrain imports and various price linkage functions.

Seed Demand

Seed demand functions are included in the model primarily for the purposes of completing the supply-demand identity relation required in the simultaneous model. The absence of a consideration for seed demand would bias the demand side of the identity downward by 1 to 4 percent.

Seed demand is specified as a function of acres planted and time, where time proxies technological changes occurring which affect seeding rates. No economic variables such as expected price, seed cost, etc. could be found to be significant in most seed demand functions in which such values were tested for significance. Economic factors which affect seed demand are incorporated through the acreage planted variable which does respond to economic factors.

It should be noted that the relevant acreage planted value for estimates of seed demand in the current crop year is acres planted for the coming crop year. Hence, given a recursive acreage planted function, the variables and parameters of the recursive acreage planted function can be substituted into the seed demand function for the acres planted variable. This allows a simultaneous solution to be obtained for seed demand.

Feedgrain Imports

Imports of feedgrains and feed grain equivalent products have ranged up to 1 percent of total supply of feedgrains in a given year. Hence, a simple feedgrain import function is specified to avoid bias on the supply side of the feedgrain identity function.

Price Linkages

Several types of domestic price linkage functions exist within the model. A set of price links relate all feedgrain prices (corn, oats, barley and sorghum). Another price link relates soybean, soymeal, and exogenously specified soyoil prices. Lastly, a set of price links relates domestic prices received by farmers to U.S. f.o.b. export prices. Further price linkage of U.S. f.o.b. wheat and feedgrain prices is performed in the international demand component of the model.

With regard to feedgrain price linkages, corn price is considered to be the key price in the feedgrain market. Oats, barley and grain sorghum prices are linked to the corn price. Allowance is made for a time trend in the price spread existing between corn and other feedgrains. The time trend effect indicates that the spread between corn price and oats and barley price has been widening, presumably because these feeds have increasingly been rejected as a desirable feed. The price spread between corn and sorghum price is indicated to be narrowing over time.

A third variable is also considered in the feedgrain price linkage functions, the ratio of the current period production of the feedgrain in question to the quantity of other feedgrains produced in the current period. This recognizes some degree of imperfect substitution between feedgrains and causes the price spread between corn and the given feedgrain in question to narrow when the given grain is in relatively short supply.

With regard to soybeans, soymeal and soyoil price relations, recognition is given to demand for soybeans for the purposes of processing the bean and producing meal as well as oil. The dominate demand for the soybean is clearly for meal production but the oil is a valuable complimentary by-product, hence when soyoil prices rise demand for soybeans and hence, soybean prices can be expected to rise. A wage variable is also included in the soybean price linkage function to proxy processing cost, hence a negative sign is hypothesized and observed.

With regard to domestic and f.o.b. export prices, three price links are estimated. Exogenous factors affecting these price spreads include the general wage rate (a proxy for changing transportation and handling cost), carryover stock levels (private and public combined) and in the case of feedgrains the current production level.

The price linkage functions specified in the model generally have good fits. However, their specification has not been deeply rooted in theory. Systematic bias in a price linkage function can create as much or more integrated model error as any other supply or demand function in the model. Hence, price linkage functions should not be treated lightly, i.e., the point to be made here is synonymous to the discussion of how much emphasis should be given to modeling the "farm-retail" price spread in a model that proclaims to consider demand at both the retail level and farm level. Serious questions are often raised as to whether transportation, processing cost, etc. which create price spreads can be handled lightly with crude aggregate proxy variables.

Table C-6.1 Seed Demand and Feedgrain Import Functions

Dependent Variable	Independent Variable				R^2	Durbin Watson	Degrees of Freedom
	Acreage of the Crop Planted (t+1)	Time	Time Squared	Constant			
Corn Seed Demand (1,000 tons)	.0050 (5.26)	-33.57 (1.81)	.34 (2.27)	752.66 (1.23)	.82	1.66	19
Oats Seed Demand (1,000 tons)	.0405 (60.14)	24.79 (2.84)	-.19 (2.75)	-807.16 (2.78)	.99	1.68	19
Barley Seed Demand (1,000 tons)	.0383 (33.93)	-14.97 (1.38)	.12 (1.28)	475.75 (1.52)	.99	2.60	19
Sorghum Seed Demand (1,000 tons)	.0037 (12.92)	-4.58 (1.17)	.04 (1.15)	133.55 (1.14)	.91	1.17	19
Wheat Seed Demand (1,000 tons)	.0345 (42.34)	48.70 (2.08)	-.38 (1.97)	-1577.08 (2.12)	.99	2.30	19
Soybean Seed Demand (1,000 tons)	.0292 (14.32)	12.43 (1.07)	-.15 (1.44)	-245.68 (.72)	.98	2.46	19
Feedgrain Imports (1,000 tons)		7967.28 (4.10)	-62.51 (3.90)	-253210.85 (4.34)	.84	1.38	19

Table C-6.2 Domestic Price Linkage Functions

Dependent Variable \ Independent Variable								
	Corn Price	Time	Ratio of Own Production to Other Feed-Grain Prod.		Constant	R^2	Durbin Watson	Degrees of Freedom
Oat Price ($/bu.)	.354 (8.13)	-.020 (8.06)	-1.797 (6.52)		1.727 (8.64)	.97	2.63	19
Barley Price ($/bu.)	.501 (4.54)	-.015 (2.62)	-6.864 (4.68)		1.839 (3.35)	.93	2.18	19
Sorghum Price ($/bu.)	.712 (2.80)	.003 (.42)	-2.160 (1.41)		.245 (.30)	.89	1.61	19
	Soymeal Price	Soyoil Price	Wage Rate					
Soybean Price ($/bu.)	.480 (6.50)	.028 (1.59)	-.261 (1.58)		.411 (.57)	.85	2.01	19
	Corn Price	Feed-grain Prod.	Feedgrain Stocks	PV1 Corn				
Feedgrain Export Price ($/ton)	43.605 (6.59)	.001 (1.80)	.001 (1.93)	10.946 (4.32)	-29.262 (1.59)	.98	1.66	9
	Wheat Price	Wheat Stocks	Wage Rate					
Wheat Export Price ($/ton)	8.565 (2.54)	-.001 (2.30)	-42.653 (4.44)		165.695 (5.52)	.97	2.53	9
	Soymeal[1] Price Paid	Wage Rate						
Soymeal Export Price ($/ton)	.888 (13.28)	-11.334 (4.26)			-75.716 (7.24)	.93		20

[1]Soymeal price paid by farmers in $/ton.

APPENDIX D

THEIL INEQUALITY COEFFICIENTS

Henri Theil has developed several numerical criterias for judging the accuracy of time series predictions. The tests basically center around the prediction model's ability to predict "turning points" (as defined by Theil) and magnitudes of change. Theil argues that

> given the considerable positive serial correlation of most economic time series, it is rather easy to predict a continuation of expansions or of contractions; and that therefore, a real success is only obtained if the end of such a one-sided movement is correctly predicted.
>
> There are four possibilities with respect to the prediction of turning points, viz.:
>
> 1) A turning point is correctly predicted; i.e. a turning point is predicted, and an actual turning point in the same period is recorded afterwards.
> 2) A turning point is incorrectly predicted; i.e. a turning point is predicted, but there is no actual turning point.
> 3) A turning point is incorrectly not predicted; i.e. a turning point is recorded, but it was not predicted before.
> 4) A turning point is correctly not predicted; i.e. a turning point is neither predicted nor recorded.
>
> The cases two and three represent failures and we shall call them turning point errors of the first kind and of the second kind.[1]

This classification can be represented schematically by the following diagram where successful turning point predictions lie in quadrants 1 and 3 and have been subdivided into under and over

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[1] Henri Theil, Economic Forecast and Policy. Amsterdam, North Holland Publishing Company, 1965, p. 28-29.

predictions of change.

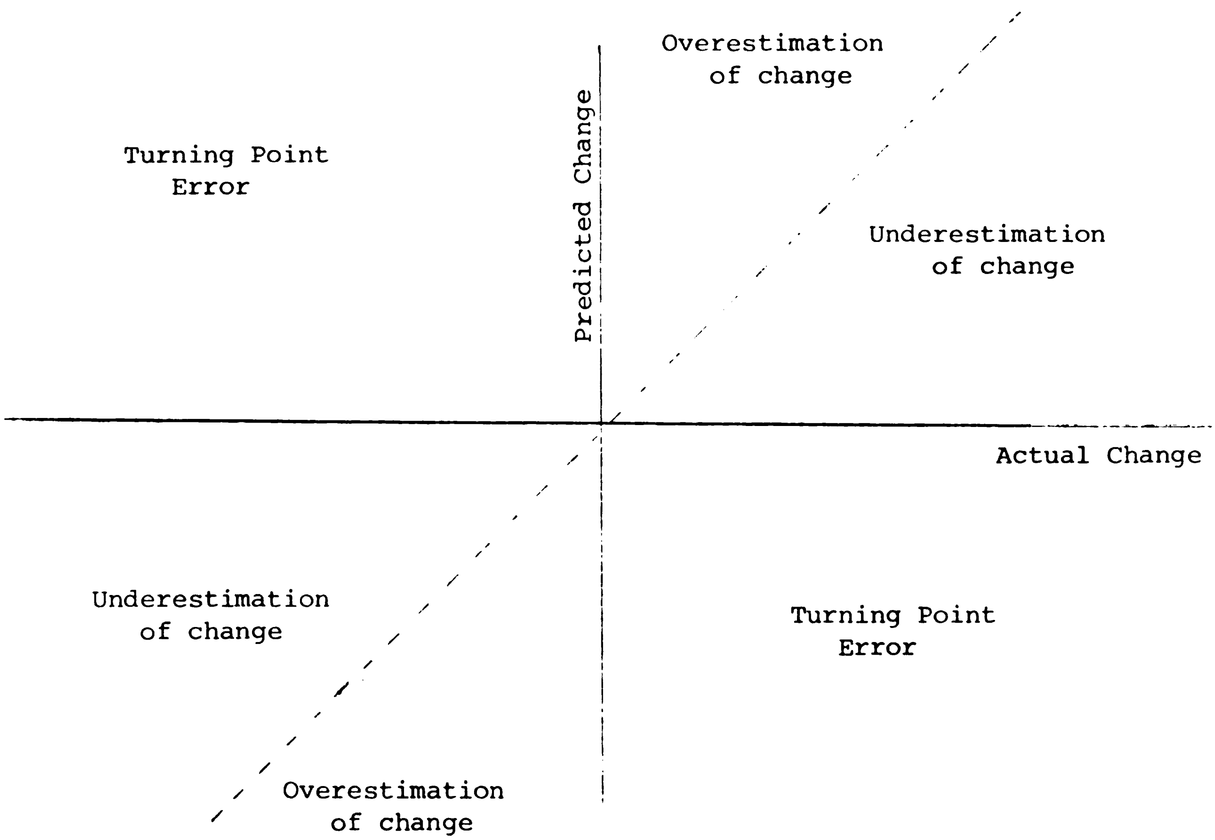

Figure D.1 Diagram of Actual and Predicted Change

The diagonal dotted line represents the "line of perfect forecast". A line passing through the origin perpendicular to this line would represent a line of "worst possible forecasts".

The preceding discussion presents the basic logic from which Theil develops his inequality coefficients which are more commonly known as "U" coefficients. Theil warns that although turning point analysis often yields valuable insights, its importance should not be exaggerated. Without a complete knowledge of how the model is functioning it is possible for the turning points of various aggregate or interlinked variables to be "predicted right for the wrong reason".

Secondly, actual and predicted turning points sometimes represent sharp peaks and troughs, but they may also be so flat as to have very little meaning as such, and sometimes actual turning points are even dubious because of errors of measurement. Lastly, the random error of the prediction may be large enough to cause, in some instances, a model to randomly correctly call or misscall a small turning point.

Theil has developed two "U" coefficients for measuring accuracy. This fact, plus confusion over the definition of each coefficient, has led to confusion in the literature in comparing U-coefficients between various models.[1] The first U-coefficient developed by Theil is presented in his book titled "Economic Forecast and Policy" and is generally referred to as U1 and defined as follows;

$$U1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - A_i)^2} \Bigg/ \sqrt{\frac{1}{n}\sum_{i=1}^{n}P_i^2} + \sqrt{\frac{1}{n}A_i^2}$$

where

P_i - The predicted change i.e. $P_t - P_{t-1}$

A_i - The actual change i.e. $A_t - A_{t-1}$

n - Number of changes considered

Confusion over U1 arises in the literature as to whether Theil's symbols P_i and A_i refer to predicted changes or predicted actual values. It is clear from Theil's underlying rationale that he was thinking in terms of first difference models throughout his discussion. Numerous presentations in the literature however, calculate U1 using value levels instead of changes in values. This typically

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[1]Raymond Leuthold presents a good discussion of this confusion in a note entitled "On the Use of Theil's Inequality Coefficient", in the May 1975 AJAE page 344-346.

leads to the calculation of a U1 coefficient much smaller than the UI coefficient Theil had in mind. The value of U1 falls between 0 and 1 (with either form of calculation) with a 0 value indicating a perfect set of forecasts and 1 representing a set of extremely bad forecasts.

It is pointed out by Leuthold[1] that changing the definition of P_i to $AP_i = P_t - A_{t-1}$ causes the numerator of the U1 coefficient to take on the same value whether levels or changes in value are used. The denominator changes depending on which approach is used. When level values are used as opposed to differences the value of the denominator increases sharply while the numerator remains unchanged with this definition. By comparison the use of levels instead of changes in Theil's definition of U1 increases both the numerator and denominator, with the denominator increasing more proportionately, resulting typically in a lower U1 when levels are used as opposed to changes.

The second U-coefficient developed by Theil is presented in his 1966 book entitled "Applied Economic Forecasting" -- generally referred to as U2 and is defined as follows by Theil;

$$U2^2 = \sum_{t=1}^{n} (P_i - A_t)^2 / \sum_{i=1}^{n} A_i^2$$

where P_i, A_i and n are defined as before. Confusion again exists as to the treatment of P_i and A_i as levels or differences; but it is

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[1] Raymond M. Luethold, "On the Use of Theil Inequality Coefficients". American Journal of Agricultural Economics. 57 (1975): 344-346.

clear that Theil intended them to be differences. Theil describes the properties of the above U-coefficient as follows;

> It is immediately seen that U = 0 only if the forecasts are all perfect ($P_i = A_i$ for all i); also, that U = 1 when the prediction procedure leads to the same RMS [RMS = $\sqrt{\frac{1}{n} \sum_{i=1}^{n} (P_i - A_i)^2}$ and is translated as root-mean-square prediction error] error as a naive no-change extrapolation. In other words, by using the inequality coefficient one measures the seriousness of a prediction error by the quadratic loss criterion in such a way that the zero corresponds with perfection and the unit with the loss associated with a no-change extrapolation. It will be clear that the inequality coefficient has no finite upper bound, which is tantamount to saying that it is possible to do considerably worse than by extrapolating on no-change basis.[1]

In general U2 appears, according to Leuthold, to be more flexible, more appropriate in a wider range of circumstances, and easier to understand and interpret than U1.

As stated previously Theil intended for his inequality concept to be used with first difference models and not actual variate models. The abuses created when the concept is applied to actual variable models deserve some discussion here since such abuses are common and have been imposed in this dissertation. One type of abuse is to simply substitute level values into Theil's equations for changes. This creates a whole new concept of an accuracy measure only indirectly related to Theil's measure. This concept is especially sensitive to additive transformations. Adding a consistent

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[1]Henri Theil, Applied Economic Forecasting. Amsterdam, North Holland Publishing Company, 1966, p. 23.

value to any series of P_i's and A_i's (defined as levels) will reduce its U1 coefficient but not the correlation coefficient between the set of P's and A's. This is why Theil has used first differences or changes. The use of changes fixes the origin from which the measure is based, i.e. in reference to Figure D.1, the origin is zero and the line of perfect forecast passes through this origin. This may not be the case when levels instead of differences are used. The scale of the variables when using the "levels" interpretation of U1 affects the denominator greatly and the numerator to a lesser extent, hence relations expressed with large scale values appear to have a better or lower U1 coefficient than relations expressed with small scale values.

A second form of abuse to the inequality concept is to use Theil's definition of U1 and U2 but to apply them to an actual variate model instead of a first difference model. To do this P_i must be calculated as $\Delta P = P_t - P_{t-1}$. This value is then used as a proxy for P_i which as defined by Theil is a first difference model's direct estimate of $A_t - A_{t-1}$ or ΔA. This appears to violate a condition of the underlying theory of the Theil inequality coefficient, namely, that each prediction considered in the set of predictions for which a coefficient is calculated be independent. Since this form of calculating P_i depends upon two forecasts of A, then ΔP as an approximation of P_i, cannot be independent of all other predictions.

Theil goes on to make a point about the condition of prediction independence which is of importance with regard to dynamic or multi-period simulation comparisons of predicted data and actual data. Theil states: "This condition [independence of predictions] is not insurmountable when the forecasts are made at the beginning of their period of prediction; but it will not be fulfilled in general when on one point of time a series of simulations predictions is made of successive values to be assumed by some variable." This is precisely the nature of a multi-period simulation run.

Despite the aforementioned problems using Theil's concept of inequality coefficients with actual variate models -- particularly multi-period actual variate models -- they are used in evaluating the NASS model, hopefully with the proper respect for the abuses performed and the limitations created.

Theil demonstrates that U1 and U2 can be decomposed into values describing the nature of the forecasting error occurring. Decomposition of U2 as presented in Theil's book "Applied Economic Forecasting"[1] is being discussed here. The logic behind this decomposition follows from the observation that if the predicted changes were regressed upon the actual changes, the resulting regression estimate should have a constant term equal to zero and a slope of one, if the predictions are unbiased. The observations of course would not fall exactly on the line but at random around it due to normally distributed disturbances. Theil shows that the mean square prediction error can be decomposed into error due to a mean bias (non zero intercept), regression (slope not equal to one), and a disturbance (random variation about the regression line).

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[1] Henri Theil, Economic Forecasts and Policy, Amsterdam: North Holland Publishing Company, 1965, p. 23.

The formula representing this decomposition is as follows:

$$\frac{1}{n}\Sigma(P_i - A_i)^2 = (\bar{P} - \bar{A})^2 + (S_p - rs_A)^2 + (1 - r^2)S_A^2$$

where

$$\bar{P} = \frac{1}{n}\Sigma P_i$$

$$\bar{A} = \frac{1}{n}\Sigma A_i$$

$$S_p^2 = \frac{1}{n}\Sigma(P_i - \bar{P})^2$$

$$S_{\bar{A}}^2 = \frac{1}{n}\Sigma(A_i - \bar{A})^2$$

$$r = \frac{\frac{1}{n}\Sigma(P_i - \bar{P})(A_i - \bar{A})}{S_p S_A}$$

The term on the left hand side of the relation represents the total error while the terms on the right, from left to right, comprise error due to mean bias, slope bias and random variance. Dividing through by the mean square error term on the left of the relation shows the three sources of error expressed as proportions which sum to one by definition.

While the decomposition of the error is interesting in itself it is also potentially useful. An "optimal linear correction" factor can be readily calculated from the information provided by the error decomposition values. The "optimal linear correction" factor intutively involves corrections which transform a regression line of predicted upon actual values, which does not have an intercept equal to zero and/or a slope equal to one, into a line that has such properties. This is done by deriving a linear correction formula of the form $a + bP_i$; that is each forecasted P_i is multiplied by some <u>b</u> and a constant a is added. The intercept and slope value of this correction function are calculated by minimizing the mean square error of the following:

$$\frac{1}{n} \Sigma(a + bP_i - A_i)^2$$

Minimization with respect to a and b yields:

$$b = \frac{\Sigma(P_i - \bar{P})(A_i - \bar{A})}{\Sigma(P_i - \bar{P})^2} = \frac{r\,S_A}{S_P}$$

$$a = \bar{A} - b\bar{P}$$

The corrected forecast (CP_i) is calculated as follows:

$$CP_i = a + bP_i$$

where a and b are found as specified above. Actually the linear correction formula is the ordinary least squares regression line obtained when P_i is regressed upon A_i. It follows then that the mean of the corrected forecast is equal to $\bar{A}$. This implies that the bias proportion of the error vanishes. It also follows that the standard deviation of the corrected forecast is rS_A which means that the regression proportion of the total error vanishes.

These properties of CP_i hold in the case where a and b are calculated from large samples with disturbance errors which tend to zero and the source of mean bias and regression bias are systematic. Corrections of this kind are useful for forecasting if it is believed that the model will continue to make the same systematic errors in the future.

In summary, the Theil inequality coefficient concept is a widely used and misused concept which has the desirable properties of being able not only to provide a measure of forecast accuracy but can also decompose the error of the forecast. The concept focuses upon the forecast model's ability to predict turning point and magnitudes of change. The concept is designed for use with first difference models. Its use in various modified forms upon actual variant models deserves cautious interpretation and warrants further study as to its exact properties.

Use of Optimal Linear Correctors in the NASS Model

The NASS model is capable of generating 10 historical forecasts and is an actual variate model. Hence decomposition of the U2 coefficient and subsequent calculation of "optimal linear correction" factors is questionable on three counts. First, lack of a large sample; second, a lack of evidence of systematic error; and three, a questionable basis for calculating a U2 coefficient for an actual variate model where P_i is proxied by $P_t - P_{t-1}$. The "optimal linear correction" factor has been calculated for several variables in the model despite these factors. The validity of doing so is left to a pragmatic test of workability, namely does it improve the tracking of the model?[1]

Soybean acres planted were selected as an experimental variable to test the optimal correction procedure. The actual variate slope and

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[1]The "add" and "mul" factors referred to in the discussion of model management features in the NASS model lend themselves well to the use of the "optimal linear correction" factors.

intercept factors were used as opposed to first difference slope and intercept values. The 10-year multi-period forecast indicated the soybean acres planted variable had .3301 percent mean bias and .0285 percent regression bias.

Imposition of the actual variate optimal linear correction function reduced the mean bias to .0570 and the regression bias to .0012. Reasons for these values not becoming zero may be any of several: first this application is for the multi-period run while the optimal linear corrector is calculated from the signle period forecast run; second, recursive error and cross model error from other components may build up and create systematic bias overtime not created in single period forecast.

Comparison of other accuracy measurers for the runs with and without the optimal correction procedures involved leave a mixed picture as to the improvement rendered in multiple period forecast by the optimal corrector.

Table D.1 Accuracy Measures for Soybean Acres Planted with and Without Optimal Linear Correction Procedure Involved

Accuracy Measure	Without Correction	With Correction
R	.9756	.9713
U2A	.7465	.6681
U1A	.0198	.0179
U1	.3237	.3526
U2	.6537	.7368
Average Bias	871.9240	324.3520
Average Absolute Error	1300.2530	1142.0020
Maximum Error	2401.9080	2518.4490
Mean Square Error	230304.1930	230304.7530
Percent Error	3.6040	3.0190
Slope	1.0498	1.0087

Correlation of predicted and actual soybean acres planted is not improved. Actual variate inequality coefficients are improved but first difference inequality coefficients are not. Average bias is significantly improved. Average absolute error, mean square error and percentage error all are improved. The slope coefficient approaches one. Maximum error is increased.

In regard to total model performance no improvement is noted, in fact average R falls to .7013 versus .7062 and percentage error rises to 11.123 versus 10.983 previously. Eight turning points are altered, three correctly and five incorrectly. More specifically soybean price estimates are not improved.

It would appear from this case that the optimal linear corrector does a good job of reducing bias in the variable under consideration but does not necessarily improve other accuracy measures.

As a further test of the usefulness of the optimal linear correction technique, acres planted to oats, acres of corn harvested for silage and acres of sorghum harvested for silage were also corrected by optimal linear correction functions using the actual variate correction function. These particular variables were chosen because they possess considerable degrees of bias due to mean and regression error. They also are recursively estimated and thus easy to correct in the context of the model program structure.

In this application of optimal linear correctors substantial improvement was obtained in overall model performance. Average percentage error for the model dropped from 10.983 to 10.584. The average simple correlation coefficient rose from .7062 to .7271. U1 dropped from .5049 to .4992 and U2 dropped from 1.0650 to 1.0338. The greatest improvement perhaps occurred in the average U2A coefficient which dropped from 1.0196 to .9344. Numerous turning points are affected but in total ten additional turning points are correctly predicted.

Without specifically listing the accuracy values altered for each variable adjusted it can be noted that average bias, average absolute error and percentage error are all greatly reduced for the variables adjusted. In addition the actual variate measures of mean bias and regression bias drop to a sum of less than five and one half percent for all variables adjusted, indicating that random error now accounts for more than 94 percent of the error for any of the four variables corrected. Previously it accounted for no more than 64 percent of the error.

Improvement from the corrections spreads through the model, particularly in functions using silage available as a variable. The more accurate estimates of acres of corn harvested for silage gives a better estimate of silage available. A noticeable improvement occurs in the non-fed beef supply and demand component. This particular segment of the model performs quite badly in the recursive model. Prior to the corrections a negative correlation of .41 and .04 were observed for non-fed beef quantity and price respectively. After corrections the correlations improved to positive values of .06 and .06 for both quantity and price. These are still quite unacceptable levels but much better than previously obtained. Estimate accuracy for beef and dairy cow numbers are also improved from simple correlation values of .889 and .902 to .922 and .917 respectively. Beef and dairy cow average percentage error figures are reduced from 5.51 and 3.85 to 4.53 and 3.32 respectively.

In general it appears that the actual variate optimal linear correction technique reduces bias and magnitudes of error but does little to "directly" improve correlation. Correlation and turning point improvements which do occur are felt to flow from improvements in cross model consistency.

As a physical demonstration of the improved tracking ability created by optimal adjustments to soybean acres planted, oats acres planted and acres of corn and sorghum harvested for silage, the following plots of actual and unadjusted multi-period forecasts and optimal linearly adjusted forecasts for non-fed beef price, non-fed beef production, dairy cow numbers and beef cow numbers are presented.

In observing the plots it is seen that very little is done to improve the distorted pattern of the predictions when optimal linear correction procedures are used but the prediction paths are generally shifted and/or rotated such that the total error and bias are reduced.

In defense of the inability of the non-fed beef model to obtain better tracking ability and of the NASS model's over-all ability to track, it should be pointed out that non-fed beef slaughter is the worst tracking functions in the model. Also under single period estimation conditions the non-fed beef model's tracking improves considerably. Recursive error and improper cycle projection over an extended period are felt to cause most of the error in the non-fed beef model.

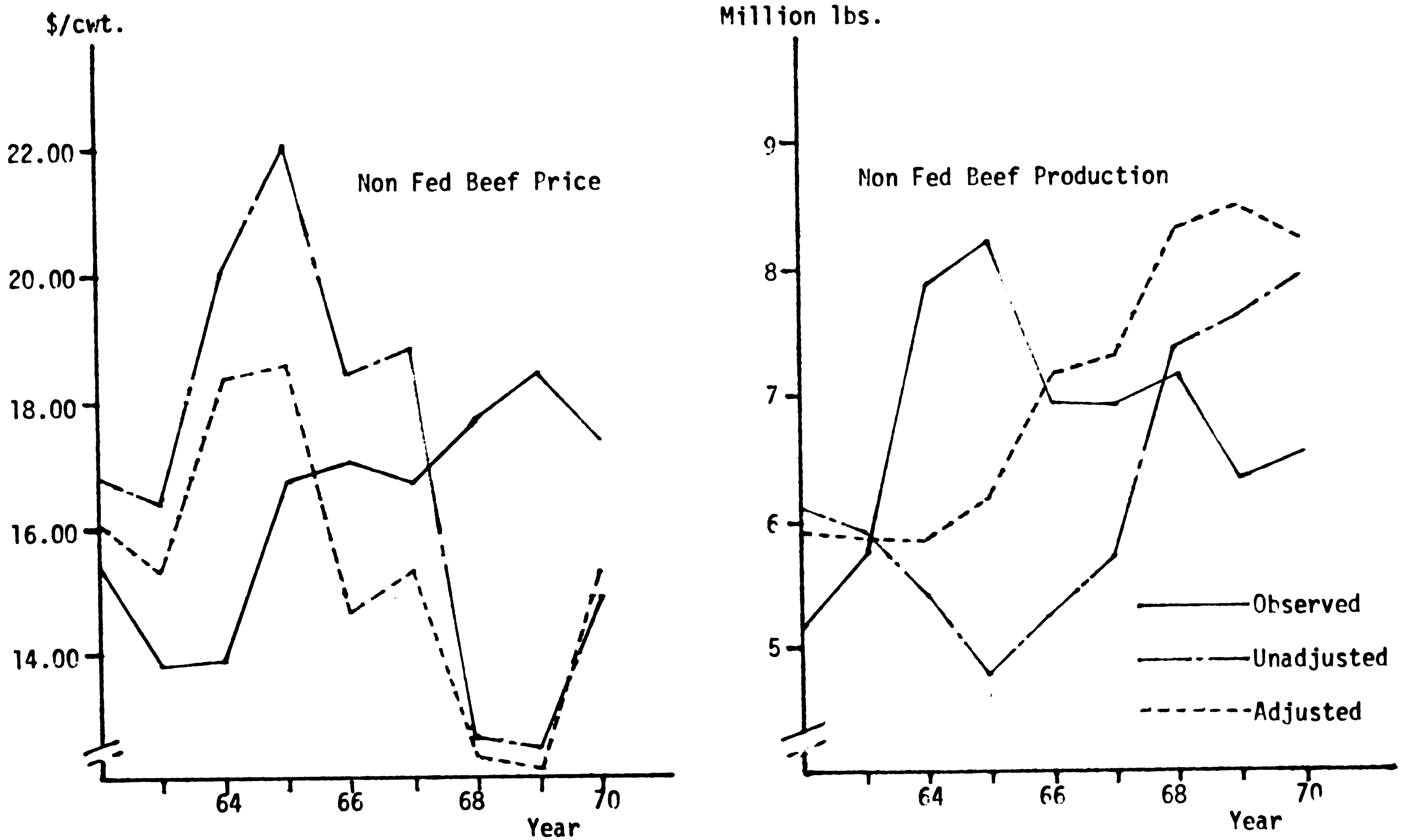

Figure AD.1. Optimal linear adjustment improvements in tracking

Figure AD.2. Optimal linear adjustment improvements in tracking

In invoking optimal correction factors in a large integrated model it appears that their application must be done step wise. That is, a number of variables can be corrected initially that are relatively independent of each other in the model structure. These corrections will affect other portions of the model. Hence any subsequent correction of other model variables should be made in light of the effect of other optimal correction function's influence upon the integrated model error structure.

An example of the intuitive rationale for a step-wise correction procedure may illustrate the rationale. Assume a ten-equation model is built where all equations except two perform perfectly on an independent basis. However, all equations are interlinked. Therefore the error of the two equations causes error in all integrated model estimates. Applying optimal correction functions to all estimates of the model is not the answer, rather the two equations should be isolated and corrected, thus yielding a perfect model. Determining the source of error in a large model and applying an optimal correction function where sources of error are created, at this stage of methodological development, appears to be a "hit and miss" art rather than a science of systematically eliminating integrated system bias.

Additional problems arise when the correction function is attempted to be used for a simultaneously estimated value. The corrected prediction should be reentered into the solution process so as to allow the effect of its alternation to spread through the model; but this may cause a shift in other factors which forces a change in the corrected estimate, i.e. the only way in which the simultaneous variable estimate can be altered is by shifting the function or changing its slope. This may set off shifts and adjustments in other functions that cause a new solution value for the variable not equal to the optimal corrected value.

In conclusion, it is felt that the use of optimal linear correction formulas for an integrated model provides promise as a procedure for eliminating systematic bias generated by the system. It should not be viewed as a substitute for eliminating bias by restructuring the model in a more correct manner or by using estimation procedure designed to eliminate bias. The implementation of the optimal linear correctors within the framework of an integrated model appears to be an artful procedure as opposed to a scientific procedure.

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