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# The impact of separating fed from nonfed beef in an econometric simulation

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# The impact of separating fed from nonfed beef in an econometric simulation

by

Dyaa Kamal Abdou Ahmed Kamal-Abdou

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# CHAPTER I. INTRODUCTION

Beef is the most significant component in the livestock-meat economy in the United States. Cash receipts from marketings of cattle and calves in 1974 were 17.9 billion dollars. This was 18.8 percent of the United States cash farm receipts and 42.3 percent of the United States cash farm receipts from livestock and livestock products. In 1974, the commercial meat production was 34.5 billion pounds of which commercial beef production comprised about 61.1 percent or 22.8 billion pounds. For the consumer, beef is a major expenditure item. In 1974, 2.6 percent of the consumer disposable income was spent on beef and 4.2 percent on all red meat.

Any valuable analysis of the livestock-meat economy in the U.S. must include an accurate understanding of the true economic relationships within the large cattle-beef sector and between beef and other meats. Craddock (5), Rahn (30), and Mann et al. (27) have constructed and improved quantitative simulations for the production and marketing of the livestock-meat economy. The purpose of those studies was twofold, to approximate and quantify the structural relationship involved; and to forecast economic variables.

Most previous meat market studies have viewed beef as a homogeneous product. However, on the basis of many criteria beef is a heterogeneous product. Davis (10) in the study designed to gain more information on the effect of systems of feedings on characteristics of beef steers, reported that there is a high degree of correlation between the type of feed, the feeding systems, and the carcass characteristics of beef cuts, i.e., carcass grade, marbling score, fat cover, and tenderness. Economists, such as Houck (17), Crom (7), Langemier and Finley (23), and Langemier and Thompson (24) have also noticed the unrealistic consequence of aggregating different beef qualities under one item. They have also noticed that different sequential order chains are involved in the production and marketing of the different beef quality items.

Most livestock market studies of the U.S. in the last 20 years tried to explain, quantify and provide forecasts for the livestock-meat economy without explicit or implicit assumption concerning the interrelationships between the livestock-meat economy in the U.S. and its counterparts in the rest of the world. The U.S. meat economy was related to the rest of the world only through imports and these in turn were assumed to depend only upon domestic factors. Thus, all the meat market models considered the United States consumers, the United States producers, and the United States import policy variables to be related only to the domestic economy in the United States. While the domestic livestock-meat and feed economy in the U.S. has historically been largely protected from economic disturbances initiated outside the U.S. borders, it has become much less so since 1972. Most of the forecasting models which ignored foreign trade did not provide satisfactory forecast for the 1972-1973 situation. According to Fox (13), several factors caused the existing econometric forecasting models to fall short in providing adequate forecast for 1972-1973 but foreign trade was critical.

> To a 1966-1972 forecasting model which includes U.S. farmers, U.S. consumers and the Commodity Credit Corporation, it becomes necessary to add the rest of the world.

The livestock-meat economy in the U.S. is becoming increasingly affected by those forces generated in other parts of the world. Market simulation models should also recognize this structural change, and to approximate the real world successfully or to build precise forecasts for the future foreign trade must be made endogenous.

Accurate quantitative economic prediction is of importance to several agencies involved in the livestock-meat economy. All managers of economic activities are faced with the need to make decisions which involve the future. The need for decisions does not wait until one is able to accurately foresee the future. Adequate forecasts provide the decision maker with valuable tools, both to simulate the various effects of alternative decisions that may be under his control and to evaluate the economic effect of those beyond his control (20). One of the most useful types of prediction is the multiple prediction (36). It refers to the prediction of several events - variables - or at least to several aspects of one event. Prediction series of sufficient length are more adequate instrument in judging forecasting quality. Computer simulation model analysis provides a tool to obtain this type of quantitative economic prediction. Naylor et al. (29, p. 3) defined simulation as "a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some component thereof) over extended period of time." The validity and accuracy of a simulation as so defined is affected by the model's ability to represent the crucial essence of the relationships that exist in the real system. Thus for constructing an econometric simulation model for the livestock-meat economy of the U.S., more consideration should be given to the accurate presentation of the true structure and relationships involved in its major component, namely, the cattle-beef sector. The econometric simulation model that represents accurately the true structure of the cattle-beef sector and provides adequate economic predictions is valuable to all economic agencies involved in the livestock-meat economy.

## Objectives of the Study

This study is conducted to achieve two main objectives. The first is to identify and quantify relationships within the United States cattle-beef sector. This is accomplished in two major ways.

1. Beef is not a homogeneous product. The cattle-beef sector in the United States is treated as being divided into fed and nonfed subsectors. In each subsector, the production and marketing phases of a separate type of beef is investigated. The first type is fed beef. Fed beef is defined as the high quality beef obtained mainly from finished cattle marketed out of feedlots. The second type is nonfed beef, which is defined as a lower quality beef obtained mainly from domestic cull dairy and beef cows, bulls, stags, and other steers and heifers that are not marketed as fed cattle.

2. The United States cattle-beef sector is not isolated from economic disturbances occurring in other parts of the world. The domestic fed and nonfed cattle-beef sector is analyzed considering the effect of the existing interrelationships between the excess supply-excess demand for beef in foreign regions in determining the level of U.S. yearly imports of nonfed beef.

The second main objective is to provide accurate intermediate term forecasts for use by economic agencies in the cattle-beef sector, and to examine the impact of separating beef into fed and nonfed in an econometric simulation for the livestock and poultry economy in the U.S.

To achieve the first objective a 43 equation quarterly recursive positive econometric model is developed and statistically estimated to accurately represent and quantify the economic relationships in the fed and nonfed cattle-beef sector. To achieve the second objective, this study is not to stand by itself and be isolated from the existing body of knowledge in the field. Rather its originality is used to modify and test an existing workable simulation model. The constructed and estimated model for the fed and nonfed cattle-beef sector is integrated with the previously constructed quarterly econometric model for the livestock and poultry economy in the U.S. - SIMU V - (27). This integration will result in the formation of the modified quarterly simulation model for the livestock and poultry economy - SIMU VI -. The modified simulation model - SIMU VI - will be used to obtain intermediate term quantitative economic prediction and information to be used by economic agencies in the livestock and poultry economy. The overall analysis will help test an important hypothesis regarding the accuracy of simulation results from SIMU V where beef is treated as a homogeneous product, and the livestock and poultry economy was explicitly assumed to be isolated from disturbances occurring inthe rest of the world against those of SIMU VI where the structure under the first objective is considered in the cattle-beef sector.

The review of the related studies along with the presentation of the structural formation for the fed and nonfed cattle-beef sector's model is presented in Chapter II. Chapter III is devoted to the discussion of the statistical methods considered in estimating the structural relations of the model, and to presenting the estimated structure of the model. Chapter IV is devoted to the presentation of the modified quarterly simulation model for the livestock and poultry economy in the U.S. - SIMU VI - where the estimated structure in Chapter III is integrated with a previously estimated quarterly simulation model for the livestock and poultry economy in the U.S. - SIMU V -. Comparison between the accuracy of the simulation resulting from SIMU VI and SIMU V models along with an evaluation of SIMU VI are also presented in Chapter IV. Summary, conclusions, and suggestions for further studies are presented in Chapter V.

# CHAPTER II. THE STRUCTURAL FORMATION OF THE FED AND NONFED CATTLE-BEEF SECTOR'S MODEL

## Introduction

This chapter is divided into two main sections. In the first section, a review of related studies is presented with critiques of their achievements and shortcomings. The second section is devoted to the explanation and presentation of the structural relations - economic model - of the econometric model for the cattle-beef sector. The structural relations are presented through functional forms and simplified diagrams. An explanation of the techniques used in deriving specific variables needed in the analysis are given in this section. In presenting the structural relations of the model, an attempt is made to provide the economic logic and theory lying behind such formation.

## Review of Related Studies

The considerations given in the model building for separating the cattle-beef sector into fed and nonfed cattle-beef subsectors is well justified through results from previous studies and actual observations. Schrader and King (32) studied the location of beef cattle feeding, taking into consideration the distinction between the supply of beef not feedlot finished and supply of beef feedlot finished. They noticed that according to 1962 data, slightly over one-half of the beef consumed comes from sources other than feedlots. This included grass fed cattle, cull animals from both dairy and beef stocks, as well as imports of meats and slaughter cattle. In this study no account was given to supplies or prices of other meat, and no distinction was made between beef from feedlot finishing and from other sources in estimating the quantity of beef consumed in each region. Thus they used one equation to estimate the demand for beef in each region. Explicitly, this study did not attempt to analyze the demand for and supply of fed and nonfed beef, but it was one of the earliest studies to consider the importance of the distinction between fed and nonfed beef from the supply side.

Langemier and Finley (23) viewed all previous studies that investigated the optimal location of cattle feeding as having two major limitations. One of the limitations was the reliance on a single demand function for beef. In this study, consideration was given to "splitting" the demand for beef into two distinct demands - fed and nonfed beef components. The single demand for beef was viewed as unrealistic, considering that consumers differentiate between different qualities of beef. The study only looked at the problem of aggregating beef of different qualities from the demand side. However, it was a useful addition to shedding more light on the procedure for splitting the demand function and for variables construction.

In 1967 a simultaneous equations beef model that allows for simultaneity between supply and demand determination for beef was formulated and estimated by Langemier and Thompson (24). In this study the supply of beef was partitioned into fed, domestic nonfed, and import components; the demand for beef was split into fed and nonfed components. The findings of this study were comparable with those of several earlier studies as far as the price flexibilities of total demand and price elasticity of total supply are concerned; it indicated that analysts have underestimated the income elasticity of demand for fed beef by focusing on all beef and overlooking the inferior income-demand relationship for nonfed beef. In this analysis twelve simultaneous equations model was formulated and estimated for the beef sector. No simultaneity was involved in seven equations. Eight of the relationships contained disturbances, of these only one equation was specified to be of the single equation form. The retail price of fed beef was represented by the average price of choice cuts, where the retail price of nonfed beef was represented by the price of hamburger. The number of nonfed cattle slaughtered was estimated from total slaughter statistics by using relative numbers of cows, bulls, and stags slaughtered under federal inspection. The imports of beef in this study were represented by one equation and were explained primarily by the price of nonfed beef and the wage rate in the meat packing industry in the U.S.

Crom (7) successfully constructed and estimated a recursive quarterly model of the beef and pork sectors of the livestock meat economy. The structure of the beef sector was divided into the cattle feeding - fed beef - subsector and the remainder of the beef - nonfed beef - subsector. Imports and exports of beef were not separated into fed and nonfed components under the assumption that about all foreign trade in beef is of a quality grade less than "good". Also, the cold storage of beef was assumed to be only related to the nonfed beef in determining nonfed beef consumption. This idea was justified by the difficulty of determining the type of the components of the beef cold storage. This model was the first dynamic model to take into consideration the separation of beef into fed and nonfed components. However, it still represents the old structure of the U.S. economy, and ignores the existing interrelationship between U.S.

and the other regions of the world in determining the nonfed import level. Also, no considerations were given to balancing the cattle stocks of farms from one year to another. This could result in unrealistic relationships between the number of cattle slaughtered and the cattle stock on farms at the beginning of the year in the simulation period. In general, the model structure presented in this study was useful in simulating ideas for the analysis on hand.

In his recent study to estimate the short-run impact of beef on U.S. meat prices, Houck (17) considered the separation of U.S. beef demand into two categories, table cuts and processed items. Estimates of direct and cross price elasticities of demand for those products were used together with elasticity estimates for other meats and other foods to assess the effect of imports on prices and upon various portions of the consumer price index. Using a partial equilibrium analysis to achieve this purpose a complete investigation of the meat sector was not attempted. In particular supply response by U.S. and foreign meat producers was not examined; the analysis was limited to short-run phenomena. One of the major achievements of the study was to provide an answer for the question, "How the imports of processed beef - nonfed beef - would have to change in order to induce, say, a one percent decrease in consumer price index?" It was concluded that imports of processed beef should increase by 140.8 percent for a 1 percent decrease in the consumer price index and 4.2 percent for a 1 percent decrease in all beef price index. The study overlooked the interrelationship between the U.S. and the other regions of the world. In the context of considering the existence of this interrelationship through positive analysis, the next question should be stated as, "With the existing short-run net export or import world wide, would it be feasible for the U.S. to decrease the consumer price index or all other subindexes by 1 percent through increasing imports of nonfed beef?" The study on hand could provide an answer for such a question.

In agriculture economics, the methodological work has been cumulative, but the empirical work has tended to be fragmented in such a way that large numbers of studies dealing with a particular subsector cannot be integrated to provide systematic understanding of that subsector (33). The complete quarterly econometric model for the fed and nonfed cattle-beef subsectors developed in this study is intended to overcome most of the limitations and make use of all the achievements of those previous related studies. This study is an attempt to provide a systematic quantitative analysis to understand the complexities and interactions in the production and marketing processes of the fed and nonfed cattle-beef subsectors in the U.S. Through integrating this model with the quarterly simulation econometric model of the U.S. livestock-poultry economy - SIMU V - (27), several hypotheses concerning the improvement of the model and the effect of national and international policies on the U.S. livestock and poultry economy could be tested and the simulation into the future could be empirically more usable in the decision making process.

## The Model Construct

In quantifying and analyzing the economic and other relationships involved in the fed and nonfed cattle-beef subsectors, this study is considered in the realm of sector analysis. The uniqueness of sector or subsector studies is not in the methodology or approach but in the scope and comprehensiveness of the research (33). The methodology utilized in developing and analyzing the econometric model to investigate the production and marketing aspects in this study is not unique.

In this section, the quarterly econometric model for the cattle-beef sector is presented. In Chapter IV, this model is integrated with a previously constructed econometric simulation model for the livestock and poultry economy in the U.S. (27). This integration will provide a base for testing several hypotheses regarding the effect of separating beef into fed and nonfed beef on the degree of accuracy in explaining the true relationships and in simulation.

The quarterly model presented in this study is recursive in nature and complete. The model is complete because each endogenous variable has a structural equation specified for its determination. It is recursive because it was constructed in such a way that each endogenous variable in the model is solely a function of either lagged endogenous variables, exogenous variables, or both. An endogenous variable of the current time period can be used as a predetermined variable in another behavioral relation of the same time period and the recursive relationship can be maintained as long as the functions are ordered in the proper sequence. In other words, in this recursive system, the endogenous variables are determined sequentially as a chain through time rather than simultaneously. The structural relations of the model are presented through behavioristic relations, definitional identities, technical and institutional relations (36, p. 18). These structural relations along with the assumptions concerning the stochastic disturbance terms complete the specification of the model. In the next chapter where numerical values for the unknown parameters in the structural relations are given, a specific structure within the model is obtained.

The econometric analysis presented is in the realm of positive economics. It deals mainly with pure analytical matters of cause and effect, without in the same time inquiring if the effect is in some sense good or desirable.

The analysis of the substitution effects between fed and nonfed production is outside the scope of this study. However, the structural relations presented consider the effect of the profitability of finishing cattle and the accumulated placements of cattle on feed upon the number of nonfed cattle marketed. Also, the cross price flexibilities for fed and nonfed beef are presented and discussed.

Quantitative studies serve the purpose of making relationships among variables explicit. The econometric model could consist only of one relationship or a group of relationships. The econometric model developed in this study is a grouping of relationships to capture the crucial features of the fed and nonfed cattle-beef sector. The model consists of 43 equations, eight of them are definitional identities, and the remaining 35 equations contain stochastic disturbance terms. The yearly cattle and calves stocks on farms are explained through 12 equations, including the equations utilized for the accounting and balancing of the number of cattle and calves from one year to another. Ten equations are devoted to the explanation of the production process of fed beef and to obtain the fed beef civilian consumption. The nonfed beef production and civilian consumption are obtained through seven structural relations. The world net export (import) along with the U.S. yearly imports of nonfed beef are analyzed through a five yearly simultaneous equations system and one identity to transfer the U.S. yearly imports to a calendar quarter basis. Another block of five quarterly simultaneous equations is designed for solving for meat prices at the wholesale market level. The last three equations are to explain the farm prices of choice steers, feeder steers, and utility cow prices. As the model is complete, there are 43 endogenous variables. The model also consists of 26 main exogenous variables, with some other derived exogenous variables.

Variables and data considerations

The calendar quarters are the basic time periods used in the model, e.g., the first quarter consists of the months January, February, and March, and so on. The variable code names, units of measure and definitions are presented in Table II-1. Data on fed and nonfed cattle and beef are rarely available in any of the widely used data sources (47, 49, 50). Most of those publications don't discuss the techniques needed for separating the readily available data on cattle and beef into fed and nonfed components. Thus, several variables used in this study were constructed and derived from secondary data to fit the analysis on hand.

Because of sampling and estimation error in obtaining the yearly cattle and calves stock variables, the number of cattle and calves on farm at the beginning of a year would not match from one year to another. This prevailing residual or difference is usually referred to as the unexplained appearance or disappearance. This number could be positive, negative, or zero. It is almost impossible and costly to try to estimate this residual variable statistically. Thus this variable, obtained from equation

Table II-1. Variable code names, units of measure and definitions

| Variable code name | Unit of measure | Description |
|---|---|---|
| APL | Thous. | Accumulated placements of cattle on feed, where $APL(I) = \sum_{i=(I-1)}^{(I-3)} PL_i$ |
| BEX | Mil. LB | Fed beef exports, carcass weight equivalent, excludes fats, offals |
| BRCN | LB | Commercial civilian consumption of broiler per capita |
| BQ | Mil. LB | United States total commercial beef and veal production BQ(L) = FBQ(L) + NFBQ(L) |
| BQOC | Mil. LB | Oceania total beef and veal production, carcass weight basis; excludes offals |
| BQSA | Mil. LB | South America total beef and veal production, carcass weight basis; excludes offals |
| BQWE | Mil. LB | Western Europe total beef and veal production, carcass weight basis; excludes offals |
| BRPW | ¢ | Price per lb broiler, Chicago, grade A ice packed |
| BULS | Thous. | Bulls 500 lb and over on farms Jan. 1 |
| CAVS | Thous. | Commercial slaughter of calves |
| CBCS | Thous. | Beef cows and heifers that have calved on farms January 1 |
| CBCS1 | Thous. | Beef cows and heifers that have calved on farms January 1 in first quarter, zero otherwise |
| CBCS2 | Thous. | Beef cows and heifers that have calved on farms January 1 in second quarter, zero otherwise |
| CBCS3 | Thous. | Beef cows and heifers that have calved on farms January 1 in third quarter, zero otherwise |

Table II-1. (continued)

| Variable code name | Unit of measure | Description |
|---|---|---|
| CBCS4 | Thous. | Beef cows and heifers that have calved on farms January 1 in fourth quarter, zero otherwise |
| CBYP | $ | Value of cattle by-products |
| CCVC | Thous. | Calf crop during calendar year |
| CCVS | Thous. | Heifers and steers, and bulls under 500 lb on farms January 1 |
| CDCS | Thous. | Milk cows and heifers that have calved on farms January 1 |
| CEOC | $ | Per capita private final consumption expenditure for South America - in U.S. $ |
| CEWE | $ | Per capita private final consumption expenditure for Western Europe - in U.S. $ |
| CFPI | - | Cattle finishing profitability indicator (CSP-CTC) $= \text{CSP(I)} - (1.705\ \text{CP(I)} + \frac{4.5}{2000}\ \text{SBMP(I)})^{*}.45 - (1.705\ \text{CP(I-1)} + \frac{4.5}{2000}\ \text{SBMP(I-1)})^{*}1.35 - (1.705\ \text{CP(I-2)} + \frac{4.5}{2000}\ \text{SBMP(I-2)}^{*}1.80 - (1.705\ \text{CP(I-3)} + \frac{4.5}{2000}\ \text{SBMP(I-3)})^{*}.9 - \text{CFSP(I-3)}^{*}.5 - \text{FLW(I)}^{*}.5 - 1.0$ |
| CFSP | $ | Price per cwt for good and choice 300-500 lb feeder calves, Kansas City |
| CFSP4 | $ | Price per cwt for good and choice 300-500 lb feeder calves and choice in the fourth quarter of calendar year |
| CHDS | Thous. | Heifers 500 lb and over being kept for milk cow replacements on farms January 1 |

Table II-1. (continued)

| Variable code name | Unit of measure | Description |
|---|---|---|
| CHOS | Thous. | Other heifers 500 lb and over not being kept for milk or beef cow replacements on farms January 1 CHOS = CHTS - CHDS - CHRS |
| CHTS | Thous. | Total heifers 500 lb and over on farms January 1 |
| CHRS | Thous. | Heifers 500 lb and over being kept for beef cow replacements on farms January 1 |
| CP | $ | Price per BU No. 2 yellow corn, Chicago |
| CPI | - | Consumer price index, 1967 = 100 |
| CSP | $ | Price per cwt choice slaughter steers, Omaha |
| CTCS | Thous. | Cows and heifers that have calved on farms January 1 (CBCS + CDCS) |
| CULS | Thous. | Commercial cows and bulls and stags slaughter |
| CUP | $ | Price per cwt slaughter utility cows, Omaha |
| D2 | | One in second quarter, zero otherwise |
| D3 | | One in third quarter, zero otherwise |
| D4 | | One in fourth quarter, zero otherwise |
| DLOSD | Thous. | Death loss and other unexplained disappearance/appearance of cattle and calves during calendar year |
| DYN | $ | Per capita disposable personal income |
| DYND | $ | Per capita disposable personal income deflated by CPI |
| FBCN | LB | Commercial civilian consumption of fed beef |
| FBPW | $ | Wholesale steer prices per cwt, Chicago, carlot basis, 600-700 choice carcass |

Table II-1. (continued)

| Variable code name | Unit of measure | Description |
|---|---|---|
| FARMS | Thous. | Farm slaughter of cattle and calves |
| FBQ | Mil. LB | Commercial production of fed beef |
| FCADW | LB | Average dressing weight for fed cattle |
| fcm | Thous. | Fed cattle marketed, 23 major states |
| FCM | Thous. | Fed cattle marketed, 39 major states |
| FLW | $ | Wage per hour for farm laborers |
| FMW | $ | Wage per hour for food marketing distribution employees |
| IMPUS | Mil. LB | Beef and veal imports, carcass weight equivalent |
| MBC | Mil. LB | Military consumption of commercial beef |
| MCN | LB | Per capita civilian consumption, milk equivalent fat solids basis |
| MFPR | - | Milk-feed price ratio |
| NEXOC | Mil. LB | Oceania net export of beef and veal, carcass weight equivalent |
| NEXSA | Mil. LB | South America net export of beef and veal carcass weight equivalent |
| NFADW | LB | Average dressing weight for nonfed cattle and calves |
| NFBCN | LB | Commercial civilian consumption of nonfed beef |
| NFBQ | Mil. LB | Commercial production of nonfed beef |
| NFBPW | $ | Wholesale utility cow beef (breaking) prices per cwt, Chicago, carlot basis, all weights |
| NIMPL | Head | Net imports of total cattle |

Table II-1. (continued)

| Variable code name | Unit of measure | Description |
|---|---|---|
| NIMPRW | Mil. LB | Rest of the world net imports of beef and veal, carcass weight equivalent |
| NIMPWE | Mil. LB | Western Europe net import of beef and veal, carcass weight equivalent |
| ONFCCR | | Other nonfed cattle marketed commercial calf slaughter ratio = TNFCM - CAVES/CAVES |
| ONFCM | Thous. | Steers and heifers marketed as nonfed cattle |
| PCN | LB | Commercial civilian consumption of pork per capita |
| PL1 | Thous. | Cattle and calves placements on feed in the first quarter of the year |
| PL2 | Thous. | Cattle and calves placements on feed in the second quarter of the year |
| PL3 | Thous. | Cattle and calves placements on feed in the third quarter of the year |
| PL4 | Thous. | Cattle and calves placements on feed in the fourth quarter of the year |
| P | Mil. | Civilian resident population |
| PMC | LB | Milk production per cow - exclude milk sucked by calves |
| PPW | $ | Wholesale price per 100 lb pork cuts, Chicago |
| SBMP | $ | Price per ton 44% soybean oilmeal, Decatur |
| T | | Trend: 1 in first quarter or first year, 2 in second quarter or second year, 10 in tenth quarter or tenth year, etc. |
| TCCA | Thous. | Actual total number of cattle and calves on farm, January 1, generated by the accounting procedure in the model |

Table II-1. (continued)

| Variable code name | Unit of measure | Description |
|---|---|---|
| TCCE | Thous. | Estimated total number of cattle and calves on farms January 1, TCCE(L) = CBCS(L) + CDCS(L) + CCVS(L) + CSTS(L) + BULS(L) + CHTS(L) |
| TNFCM | Thous. | Total nonfed cattle and calves marketed TNFCM (I) + CULS(I) + OTHCM(I) + CAVES(L) |
| TRCN | LB | Commercial civilian consumption of turkey meat per capita |
| TRPW | $ | Wholesale turkey price, New York, 8-16 lb hens |
| UNEMP | % | Unemployment rate |
| VP | $ | Price per cwt choice veal calves, South St. Paul |
| $ | | The first difference of a variable |

II-9, was added to the death loss number of cattle and calves each year. This new variable, DLOSD(L), was then used as an exogenous variable in the model.

Data on fed cattle marketings from the major 23 states, fcm(I), are readily available from secondary sources (46). The number of fed cattle marketed from these 23 states accounts for 96 percent of the total number of fed cattle marketed in the U.S. The fed cattle marketings from 39 states, FCM(I), accounts for 98-99 percent of those marketed in the U.S. A regression analysis was used to convert fcm(I) to FCM(I). Since the commercial slaughter number of cattle and calves was used in the model, this addition in the presentations of fed cattle marketings is desirable.

Nonfed cattle marketings were calculated by subtracting the number of fed cattle marketed from the 39 major states from the total number of cattle commercially slaughtered. The number of cows, and bulls and stags as a percentage of total federally inspected cattle slaughter was assumed to be the same as for those slaughtered commercially. These percentages were applied to the total cattle commercial slaughter, and the number of cow culls, and bulls and stags commercially slaughtered was obtained, CULS(L), prior to 1973. This number was subtracted from the total nonfed cattle marketings obtained before to get the number of steers and heifers that were slaughtered as nonfed cattle, ONFCM(L). The number of calves slaughtered commercially was taken as a separate component of the nonfed cattle marketings. Thus, TNFCM(L) was obtained as follows: denote cows as % of total cattle slaughter under F.I.(I) by C(I) and bulls and stags % of total cattle slaughter under F.I.(I) by B(I); then C(I)*total number of cattle under commercial slaughter (I) + B(I)*total number of cattle under commercial slaughter (I) = CULS(I). Total cattle under commercial slaughter (I) - FCM(I)=NFCM(I), NFCM(I) - CULS(I) = ONFCM(I), CULS(I) + ONFCM(I) + CAVS(I) = TNFCM(I).

To get the average dressing weights for fed and nonfed cattle and the fed and nonfed beef production, the numbers of CULS(I), ONFCM(I), and CAVS(I) as percentage of TNFCM(I) were calculated for each quarter. Each percentage was multiplied by the published dressing weight for each component. These products were added together to get the nonfed cattle average dressing weight NFADW(I). The number of TNFCM(I) was then multiplied by NFADW(I) for each quarter to get the total nonfed beef production for that quarter, NFBQ(I). This number was subtracted from the published total production of beef and veal for each quarter to get the fed beef total production, FBQ(I). FBQ(I) was then divided by FCM(I) to obtain the average dressing weight for fed cattle.

The cattle and calves inventory classes are divided by sex and weight in all USDA publications since 1970. The data before 1970 were classified and reported according to sex and age. The data used in this study - from 1952 until 1964 - were calculated by estimating the average existing relationship between data on sex and age with data reported on sex and weight from 1965-1970. These percentages were then used to convert the available data on sex and age to the needed data on sex and weight as follows:

CBCS(L) = cows and heifers 2 years and over x 0.973317

CCVS(L) = calves x 1.02785

CHRS(L) = other heifers 1-2 years old x 0.64375

CHDS(L) = heifers 1-2 years old kept for milk x 1.1565

BULS(L) = bulls 1 year and older x 1.143

The data for disposable income for other regions in the world were not readily available in series long enough to be used in the analysis. The private final consumption expenditure data for those other regions were obtained and used in the model. The available data are mainly in terms of domestic currency. It was then converted to U.S. dollars through using the exchange rates, midpoint rates and end of the period (40). This procedure was done for each country, then the sum was obtained to get the region's total. The region's total private final consumption expenditure was then divided by the region's total population - midyear estimates - to get the per capita private final consumption expenditure for each region, e.g., CEWE(L), CEOC(L). The variable BQ(L) for each region was obtained through summing the beef and veal production over each country in that region. The availability of data restricted the length of the time period used in the analysis of the world trade. Those yearly observations were only available consistently from 1960 until 1973. All the other data used are obtained directly from secondary sources (Table II-1).

### The structural relations

The structural relations represent the sequential ordering of the production and marketing activities in the fed and nonfed cattle-beef sector. The interdependently formulated relationships and the simultaneous subsets are integrated with the recursive structure in a manner which retains this sequential ordering. A visual representation of the model is presented in Figure II-1. Figure II-2 represents an arrow scheme for a complete representation of the variables interrelationships and ordering.

Inventory relations and the accounting procedure The decision to increase or decrease beef production usually is realized through increasing or decreasing the number of cattle and calves on farms or through increasing or decreasing the average weight of slaughtered animals. The number of cattle and calves on farm is a good indicator for the effect of economic and other factors on the livestock industry. Annual data on cattle number, since 1867, show seven cycles in cattle numbers. The length of the upswings has remained about constant, the length of the liquidation phases or downswings has tended to become shorter. Many economic and physical factors are responsible in affecting the cyclical swings in cattle number. The occurrence of drought conditions, over-

Figure II-1. Visual representation for the fed and nonfed cattle-beef sector; rectangles represent variables and circles represent prices

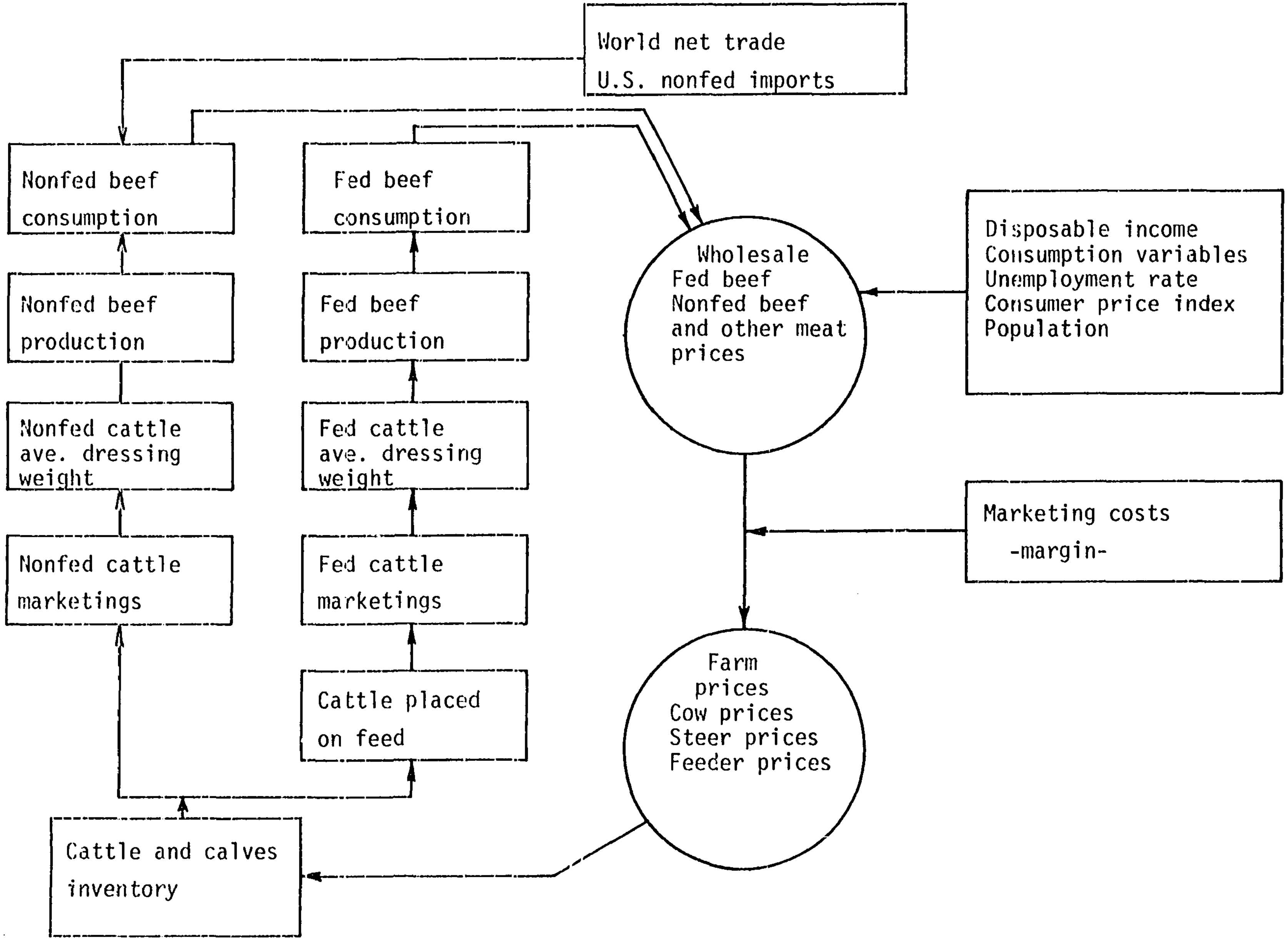
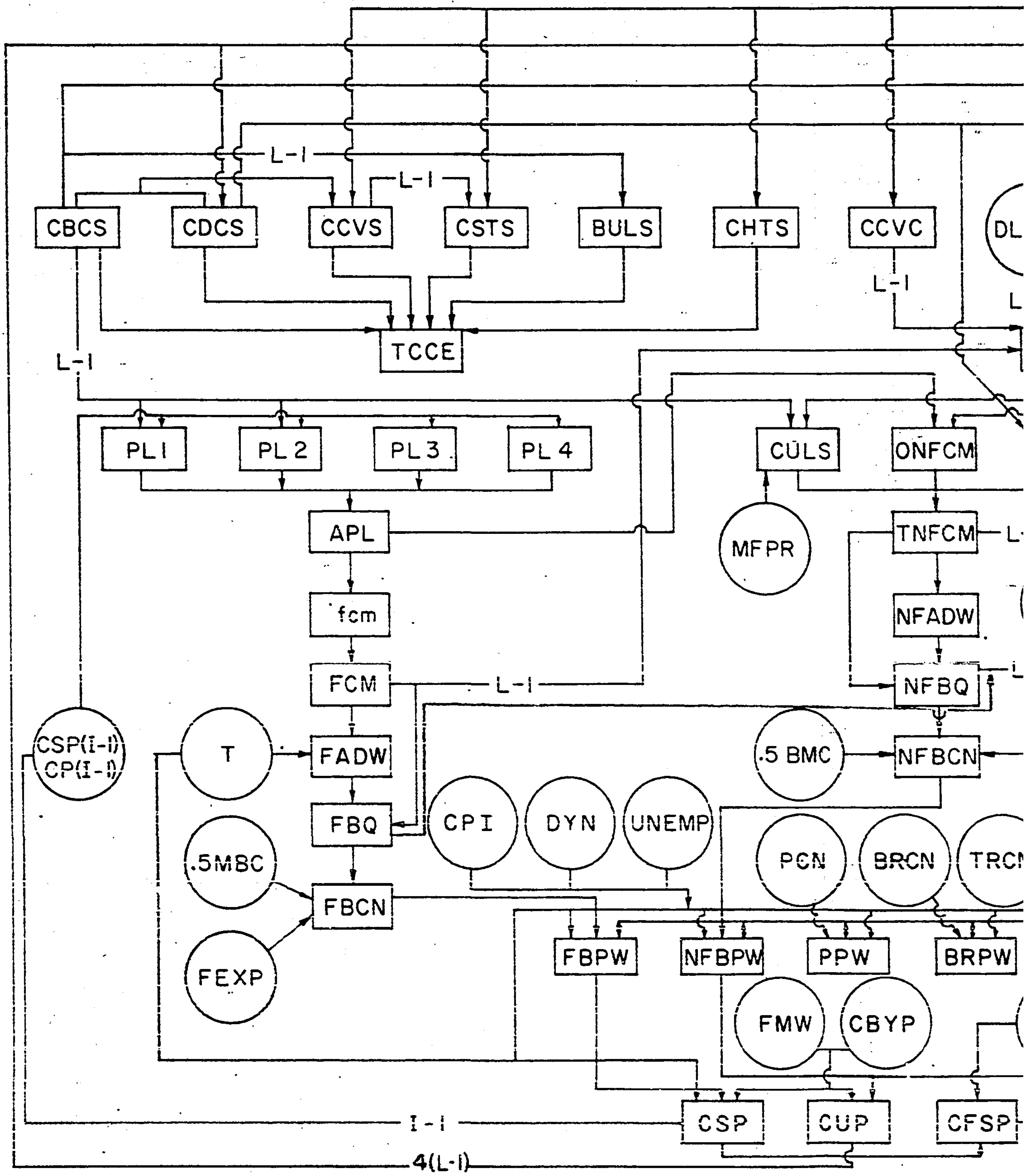
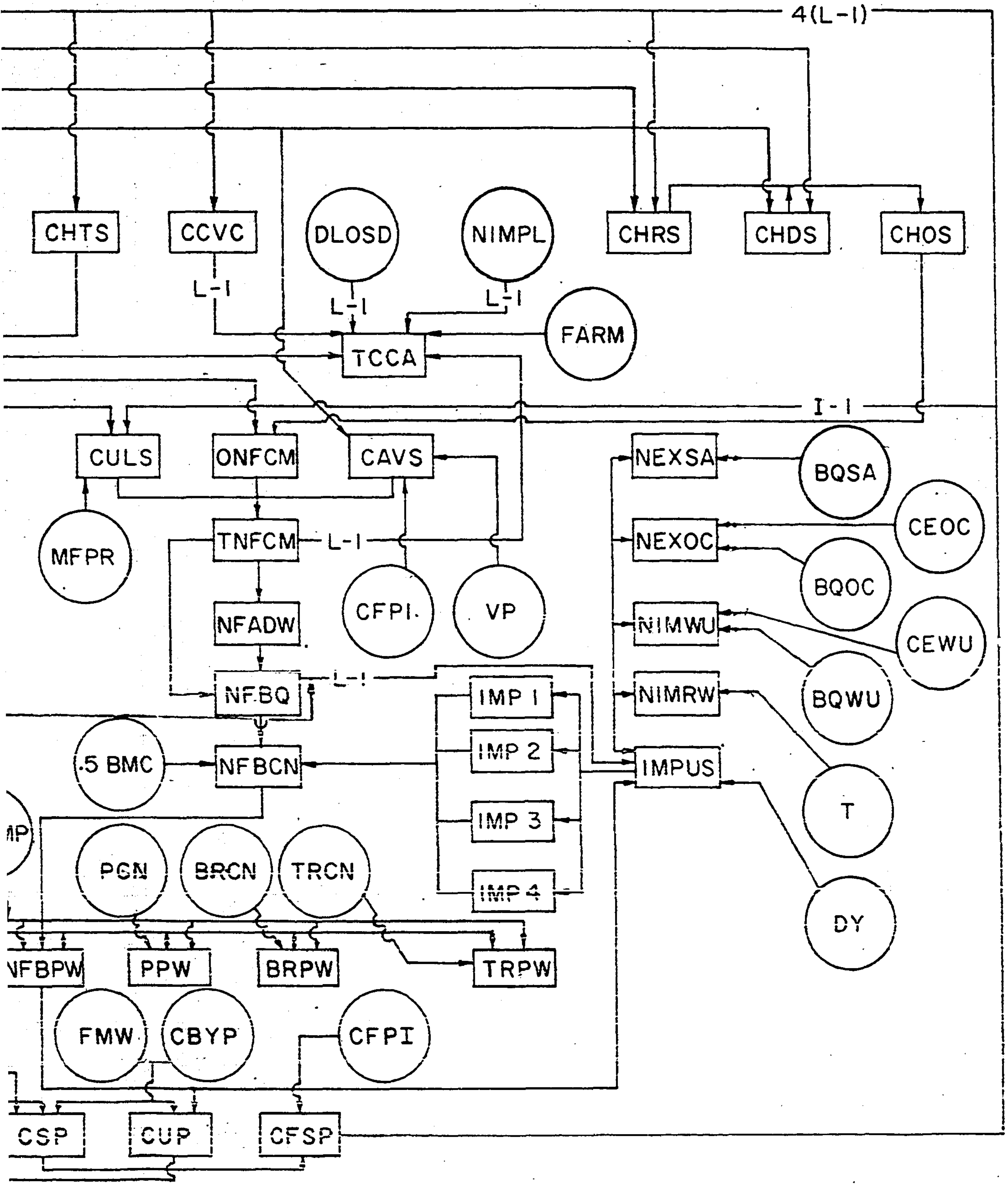

World net trade
U.S. nonfed imports
Nonfed beef consumption
Fed beef consumption
Nonfed beef production
Fed beef production
Nonfed cattle ave. dressing weight
Fed cattle ave. dressing weight
Nonfed cattle marketings
Fed cattle marketings
Cattle placed on feed
Cattle and calves inventory
Wholesale Fed beef Nonfed beef and other meat prices
Disposable income
Consumption variables
Unemployment rate
Consumer price index
Population
Marketing costs -margin-
Farm prices
Cow prices
Steer prices
Feeder prices

Figure II-2. Schematic diagram of the economic structure of the fed and nonfed cattle beef sector in the United States; rectangles represent endogenous variables and circles represent exogenous variables


L-1
L-1
CBCS
CDCS
CCVS
CSTS
BULS
CHTS
CCVC
DL
L-1
L
TCCE
L-1
PL1
PL 2
PL 3
PL 4
CULS
ONFCM
APL
MFPR
TNFCM
L
fcm
NFADW
FCM
L-1
NFBQ
L
CSP(I-1)
CP(I-1)
T
FADW
.5 BMC
NFBCN
FBQ
CPI
DYN
UNEMP
.5MBC
PCN
BRCN
TRC
FBCN
FEXP
FBPW
NFBPW
PPW
BRPW
FMW
CBYP
CSP
CUP
CFSP
I-1
4(L-1)


4(L-I)
CHTS
CCVC
DLOSD
NIMPL
CHRS
CHDS
CHOS
L-I
L-I
L-I
FARM
TCCA
I-I
CULS
ONFCM
CAVS
NEXSA
BQSA
MFPR
TNFCM
L-I
NEXOC
CEOC
BQOC
NFADW
CFPI.
VP
NIMWU
CEWU
NFBQ
L-I
IMP 1
BQWU
NIMRW
IMP 2
.5 BMC
NFBCN
IMPUS
T
IMP 3
PGN
BRCN
TRCN
IMP 4
DY
NFBPW
PPW
BRPW
TRPW
FMW
CBYP
CFPI
CSP
CUP
CFSP

stocking of grazing lands, and depressed economic conditions resulting in widespread selling of cattle have triggered liquidation phases (2). The decision to change the inventories of cattle and calves is implemented through changing the culling rate and the number of cattle kept for replacements.

*Beef cow inventory CBCS(L)* The cyclical nature of cattle numbers has been confined almost entirely to the beef cattle cycle. The cattle cycle can then be more properly called a beef cattle cycle. The major factor that determines the profitability of expanding, maintaining, or reducing the cow herd size is the producer's experience concerning the feeder calf price. The feeder calf prices of the past experience is represented by the feeder steer prices in the fourth quarter lagged two years. The first difference of the same variable has the effect of indicating the position in the cycle, and is considered as a fine tuning variable in explaining the beef cow inventory. The inclusion of the one-period lagged CBCS(L-1) has the advantage of stabilizing the simulation into the future. Statistically, this variable makes up for the exclusion of the intercept since it would capture the effect of all other omitted variables.

CBCS(L): CFSP4(L-2), $ CFSP4(L-1), CBCS(L-1) II-1

*Dairy cow inventory CDCS(L)* The milk cow and heifer inventory number has declined to less than one-half from 1950 to 1970. This decline in the size of dairy cow and heifer inventory is associated with several economic factors. The milk production per cow along with the per capita human consumption of milk are influencing the decision of expanding or reducing the dairy cow and heifer inventory. Given other factors are held the same, the increase in the production of milk per cow in a given year tends to decrease the inventory number kept for milk production by the beginning of next year. The same amount of milk production could be obtained through fewer dairy cows. Since the choice of a decision concerning the change of the dairy herd size involves other alternatives, one of those alternatives is to produce calves or finish heifers; the average milk-feed price ratio in the previous year was used in the specification of this structural relationship. The effect of milk prices was investigated, however, in estimation it was always associated with an unexpected negative sign. A hypothesis that the dairy cow producers follow more closely the cow prices in their decision to adjust the number of dairy cows was then examined. This hypothesis was not rejected and the utility cow price at the fourth quarter of the previous year was included in the structural relation.

CDCS(L): CUP4(L-1), MFPR(L-1), PMC(L-1), MCN(L-1) II-2

<u>Calf inventory CCVS(L)</u> The number of heifers, steers and bulls under 500 pounds on farms January 1 of a given year is affected mainly by the number of total cows and heifers - dairy and beef - that have calved on farms at the beginning of the previous year. The decision to keep or sell for slaughter is thought to be most affected by the feeder calf prices in the fourth quarter of the previous year.

CCVS(L): CTCS(L-1), CFSP4(L-1) II-3

<u>Steer inventory CSTS(L)</u> The number of steers 500 pounds and over on farms at the beginning of the year is mainly a function of the calf inventory on farms January 1 of the previous year. The feeder steer calf prices in the fourth quarter of the previous year is the economic

variable included to explain the variation in the number of steers.

CSTS(L): CCVS(L-1), CFSP4(L-1) II-4

*Bulls inventory BULS(L)* Bulls 500 pounds and over on farms at the beginning of the year represent a very small percentage of the total cattle on farms. The inclusion of this structural relation permits a complete estimation of all classes of cattle on farms. Bulls inventory is expressed as a function of beef cows and heifers on farms at the beginning of the previous year, and a yearly time trend variable. The association of CDCS(L-1) was investigated but was not included in the reported specification due to the rise of an unexpected negative sign of the associated parameter.

BULS(L): CBCS(L-1), T(L) II-5

*Total heifers inventory CHTS(L)* The total number of heifers 500 pounds and over on farms at the beginning of the year is a function of the calf crop in the previous year, which by that time could reach the weight equal to or greater than 500 pounds. The feeder calf steer price in the fourth quarter of the previous year and its first difference are used as other explanatory variables in this specification.

CHTS(L): CCVC(L-1), CFSP4(L-1), $ CFSP4(L-1) II-6

*Total estimated cattle and calves TCCE(L)* The previous six cattle and calf inventory variables represent the complete components of the cattle and calf inventory at the beginning of the year. Each of the previous six variables are estimated statistically according to the specifications discussed before. The sum of those six variables represents the total estimated number of cattle and calves on farms January 1 of a given year.

TCCE(L) = CBCS(L) + CDCS(L) + CCVS(L) + CSTS(L) + BULS(L) +
CHTS(L) II-6

The variable TCCE(L) will be compared later to the actual number of total cattle and calves on farms January 1 obtained through balancing the model. The procedure used to balance the cattle movement from one year to another is discussed later in this section.

Calf crop CCVC(L) The calf crop during the year is a function of the total number of cows and heifers on farms at the beginning of the year. The parameter associated with that variable should approximate the calving rate. The feeder calf steer price at the fourth quarter of the previous year is another variable that would affect the calf crop from the producer's point of view.

CCVC(L): CTCS(L), CFSP4(L-1) II-8

The accounting procedure One of the shortcomings in the previous models was the unbalance of the number of cattle and calves on farms January 1 from one year to another. This problem will result in a creation or disappearance of cattle and calves through model's estimation and simulation. The number of nonslaughtered cattle and calves would not show in the next year's stock, or for a given year the number of slaughtered animals could be more than that available on farms at the beginning of that year. This problem has disturbed the role of the positive econometric model in representing the real economy and the movements of cattle from one production stage to another. In order to overcome this problem and to balance the number of cattle and calves in the simulation period, a correction procedure is added to the model.

The estimates of the components of TCCE(L) are used as predetermined variables later in the model, and would affect the number of cattle placed on feed and those marketed without being finished and hence affect the rest of the system. In order to correct those variables before they are used as predetermined variables, an accounting equation is placed into the inventory section. This identity equation is used to obtain the total number of cattle and calves that should be on farms January 1 of year (L), TCCA(L).

$$\text{TCCA}(L-1) + \text{CCVC}(L-1) + \text{NIMPL}(L-1) - \text{FCM}(L-1) - \text{NFCM}(L-1) - \text{DLOSD}(L-1) = \text{TCCA}(L) \qquad \text{II-9}$$

For the number of cattle and calves to balance through the system, TCCE(L) and its components should be corrected to match TCCA(L). The correction procedure is as follows:

$$\text{TCCA}(L)/\text{TCCE}(L) = K(L)$$

where K(L) is the ratio between the total number of cattle and calves that should be on farms January 1 through balancing the system and those obtained through summing the estimated stock variables. Each individual component of TCCE(L), i.e., an estimated stock variable, is to be corrected through scaling by K(L)

$$\sum_{i=1}^{6} K(L)\, S_i = \text{TCCA}(L)$$

where $S_i$ is a stock variable, i=1, ...6, the components of TCCE(L). The corrected stock variables (components of TCCE(L)) are then used as predetermined variables in the system, and the number of cattle and calves would balance from one year to another through the simulation period.

Beef cow replacement CHRS(L) The number of heifers 500 pounds and over that has been kept for beef cow replacement is determined mainly by the number of beef cows and heifers on farms at the beginning of that year and the phase or the position on the cycle which is represented by the first difference of the same variable. If CBCS(L) increases from last year's level, relatively more beef cows are expected to be kept for replacement. Feeder calf steer prices in the fourth quarter of the previous year, CFSP4(1-1), is another economic variable to be taken into consideration in deciding upon the level of CHRS(L). The higher the price, the greater is the likelihood of selling cows, and the need to keep young cows for replacement is greater accordingly.

CHRS(L): CBCS(L), $ CBCS(L), CFSP4(L-1) II-10

Dairy cow replacements CHDS(L) Using the same argument presented in the structural relation for CHRS(L), heifers 500 pounds and over that have been kept for dairy cow replacement are specified to be a function of dairy cows and heifers that have calved on farms at the beginning of the year, CDCS(L), and its first difference, $ CDCS(L). CUP4(L-1) is also included in the specification; a high price of utility cows at that time period will tend to increase the sales of older cows, and hence replacements by younger cows are needed.

CHDS(L): CDCS(L), $ CDCS(L), CUP4(L-1) II-11

Other heifers inventory CHOS(L) Other heifers 500 pounds and over are those not being kept for beef or milk replacement and they actually represent the pool from which the nonfed cattle are drawn for slaughter.

CHOS(L) = CHTS(L) - CHRS(L) - CHDS(L) II-12

This procedure and specification to obtain CHRS(L), CHDS(L), and CHOS(L) are approximating the actual thinking of producers and the mechanism involved in the industry.

Those several classes of cattle and calves inventory on farms at the beginning of the year are considered as a pool from which a specific number are drawn for slaughter each year. Depending upon feeding profitability, choice steer prices, feeder steer prices, feed costs and other general economic factors, the producer may decide to finish cattle for slaughter, slaughter cattle or calves without finishing, retain or hold back slaughter if expected profit is not achieved or more profit is expected in a future point of time. According to the majority's choice of action from the previous options, the number of cattle on farms is changed from one year to another. Also, the ratio of fed to nonfed cattle slaughtered is changed. In this study, the profitability of feeding and the rate of substitution involved between marketing finished or nonfed cattle are not investigated explicitly.

Fed beef production and consumption relations The number of cattle reported on feed as of January 1 has increased almost constantly since the mid 1930's. It was estimated that the number of cattle classified as being fed before being marketed increased from 10.7 million head in 1955 to 20.6 million in 1960 and reached over 23 million in 1974.

Placement of cattle on feed PL(I) Some of the cattle inventory are placed on feed by farmers, ranchers or feedlot operators. For many years the number of cattle placed on feed was characterized by great variations among seasons. Until 1960-1962 the number was greater for the fall quarter - second calendar quarter - April, May and June. However, the leveling of the quarterly placements has been noticed lately.

The cattle placed on feed differ in number from one quarter to another, and also it differs with respect to sex and grades. Almost 70 percent of the placements are steers, nearly 30 percent are heifers, and less than 1 percent are cows and other cattle. This percentage differs from one area to the other. Over the long run the percentage of heifers on feed is expected to increase as a result of improving calving percentage and longer production life of beef cows. However, the cattle cycle is the main factor affecting the year-to-year ratio of steer to heifer placements (2). When the beef cattle cycle levels out or decreases more heifers will be available for feeding. When increased numbers of cattle are needed, a higher proportion of the heifers must be retained for the breeding herd.

Several economic and physical relationships should be considered in specifying the number of cattle placed on feed in a given calendar quarter of the year. Calving rate, culling rate, and an economic profitability indicator - to measure the tendency to adopt one of the options available to the producers, namely, to sell the cattle for slaughter or as feeder cattle - are some of the variables that should be considered in that respect.

The factors explaining the number placed on feed and the inventory number - the pool - from which the cattle are withdrawn and placed on feed differ between quarters. Thus, the timing according to weights and physical conditions should be given special consideration in explaining placement on feed for each quarter. In the first and second quarters of the year, there is a higher degree of association between the calf crop at last year and the cattle placed on feed. The number of beef cows and heifers on farms at the beginning of the previous year, CBCS(L-1), approximates CCVC(L-1) and was used in specifying this structural relation. The economic indicator for the profitability of feeding that would affect the placements was included in each quarter. The choice steer prices of the previous quarter divided by the corn price of the previous quarter were used as a feeding profitability indicator in each quarter. Steers, heifers and bulls under 500 pounds on farms at the beginning of the year, CCVS(L), are considered the significant factors affecting the number placed on feed in the third and fourth quarters in this specification. By that time, most of those calves will be ready for finishing before slaughter.

PL1(L): CBCS(L-1), CSP(I-1)/CP(I-1) II-13

PL2(L): CBCS(L-1), CSP(I-1)/CP(I-1) II-14

PL3(L): CCVS(L), CSP(I-1)/CP(I-1) II-15

PL4(L): CCVS(L), CSP(I-1)/CP(I-1) II-16

Fed cattle marketings fcm(I) There is a high degree of association between the number of cattle placed on feed in the past few quarters, accumulated placements, and the fed cattle marketed in a given quarter of the year. The problem of specifying the structural relations to explain fcm(I) was narrowed down to the choice of the appropriate time lag involved in estimating these accumulated placements. The appropriate accumulated placements for a given quarter was decided upon through trial and error using regression analysis.

$$APL(I) = PL(I-1) + PL(I-2) + PL(I-3) \qquad \text{II-17}$$

Best results were obtained where the placements were accumulated equally for each quarter. Thus, the summation of the number of cattle placed on feed in the previous three quarters was used. The specification of the relation between fed cattle marketings and accumulated placements allows for variation in the level and rate of marketings between quarters.

Fed cattle marketed from the 23 major states represent about 96 percent of the total fed cattle marketings in the United States. Data on the fed cattle marketed for those major 23 states is more readily available, and was used in this stage.

fcm(I): APL(I), APL2(I), APL3(I), APL4(I), D2(I), D3(I), D4(I) II-18

Fed cattle marketings FCM(I) The reported number of fed cattle marketings for 23 states was transformed through a regression equation to get the 39 states fed cattle marketings. Marketings from those 39 states represent about 98 to 99 percent of the U.S. total.

FCM(I): fcm(I) II-19

Fed cattle average dressing weight FCADW(I) The fed cattle average dressing weight was first thought to be closely associated with the profitability of feeding in the previous quarter, CFPI(I-1). This variable lagged one and two time periods was investigated in separate specifications, however, it was excluded along with other profitability variables tried earlier because of unexpected negative sign of the coefficients associated with them. Quarterly time trend variable, T(I), was the only needed explanatory variable in this structural relation, since the variation of the level of the FCADW(I) between quarters was not statistically significant through F-test of homogeneity.

FCADW(I): T(I) II-20

Fed beef production FBQ(I) The commercial fed beef production is defined as a product of fed cattle marketed FCM(I) and the average dressing weight of fed cattle FCADW(I). This relationship is approximated through specifying a structural relation - technical equation - containing those two variables. The variation of the level of FBQ(I) between quarters was statistically significant. From examining the specification of the previous two relationships, this seasonal variation in the fed beef commercial production seems to come about as a result of the seasonal variation in the level of the fed cattle marketed.

FBQ(I): FCADW(I), FCM(I), D2(I), D3(I), D4(I) II-21

Fed beef per capita civilian consumption FBCN(I) In this study the fed beef per capita consumption is also considered as the per capita supply available for civilian consumption. It is obtained through the identity equation

FBCN(I) = [FBQ(I) - .5 MBC(I) - BEXP(I)]/P(I) II-22

Fifty percent of the military consumption of beef and beef exports are subtracted from the total fed beef production. This amount was then divided by total civilian population for a given quarter. Following Crom (7), the total military consumption of beef is assumed to be divided equally between fed and nonfed beef products. The change in the beef cold storage (the beginning stock of the period or ending stock of previous quarter) was calculated to be 0.89 percent of the U.S. beef consumption, in the average, for any quarter from 1970 until 1973. In some studies (7) this cold storage variation (the beginning stock of the period) was arbitrarily assumed to consist only of nonfed beef and thus was only considered when obtaining nonfed beef consumption. Given the small contribution and role of the change in cold storage quantities in adjusting demand and supply for the past years in the beef industry, this variable was omitted from the analysis. It is thought that the insignificant error that may result from this omission is favored over the specification error resulting from assuming the whole quantity is one type of beef and the complexity and cost involved in estimating the cold storage variable.

*Nonfed beef production relations* In examining the production and marketing relations in this nonfed cattle-beef subsector, the same causal chain is used as in the fed cattle-beef subsector. The nonfed cattle marketings is investigated first, then the nonfed cattle average dressing weight relation. This is followed by considering the nonfed beef production technical relation, and finally the per capita nonfed beef civilian consumption is obtained.

*Nonfed cattle marketings* Nonfed cattle are divided into cull dairy and beef cows plus bulls and stags, CULS(I), and nonfed steers and heifers, ONFCM(I). Calves slaughtered CAVS(I) are considered with this nonfed subsector. Specific structural relations are developed to explain each. Total nonfed cattle marketings, TNFCM(I), are then obtained through an identity equation for the sum of the above three classes.

*Culls cows, bulls and stags marketings CULS(I)* Data on this variable was developed through the techniques explained in the previous section. The level of culls, bulls and stags marketed depends largely on the number of cows stocked on farms; the beef cows and heifers on farms at the beginning of the year was included to approximate the total. Also, the decision to slaughter the cow or to keep it depends upon the profitability of that operation. One indicator for this phenomenon is the milk-feed price ratio. When the price of feeder calves gets higher, the producers will more likely tend to keep the cows for calving and nursing baby calves in order to capture some profit that may result with this high price. Thus the cow slaughter level is expected to be negatively associated with the feeder calves prices.

CULS(I): CBCS1(I), CBCS2(I), CBCS3(I), CBCS4(I), MFPR(I),
CFSP(I-1), D2(I), D3(I), D4(I) II-23

This specification allows for variations in the culls marketed number as well as the cull rate between quarters.

*Nonfed steer and heifer marketings ONFCM(I)* This structural relation is devoted to explaining the number of steers and heifers that are commercially slaughtered, but are not marketed through feedlots. The more cattle placed on feed in the previous three quarters, APL(I), the less nonfed steers and heifers will be marketed in that quarter. Thus, APL(I) for each quarter was included in the specification. Most of the nonfed heifers come mainly from a pool of heifers 500 pounds and over that have not been kept for milk or beef cow replacement, CHOS(L), on farms at the beginning of the year. The variable CHOS(L) was included accordingly. The cost of feed approximated by corn price in the previous quarter, CP(I-1), was included in the structural relation. Also, dummies to allow for change in the level of ONFCM(I) between quarters were included.

ONFCM(I): APL(I), APL2(I), APL3(I), APL4(I), CHOS(I), CP(I-1),
D2(I), D3(I), D4(I) II-24

*Calves commercially slaughtered CAVS(I)* The number of calves commercially slaughtered depends mainly upon the number of dairy cows on farms at the beginning of the year. However, the producers have a choice of selling the calf as a vealer instead of keeping it until it reaches 300-500 pounds in weight. The inclusion of the vealer price, VP(I), represents this phenomenon in the structural relation. As the vealer price rises the potential for keeping the vealer to become a calf is small, and thus smaller calf slaughter number is realized for that quarter. Dummy variables were added to the specification to allow for changes in the level of calf slaughter between quarters.

CAVS(I): CDCS(I), VP(I), D2(I), D3(I), D4(I) II-25

Total nonfed cattle marketings TNFCM(I) The total nonfed cattle and calves that are marketed in a specific quarter is given by

TNFCM(I) = CULS(I) + ONFCM(I) + CAVS(I) II-26

Nonfed cattle average dressing weight NFADW(I) As the average dressing weight of calves is less than that of other classes of the nonfed cattle marketed, the average dressing weight of nonfed cattle is expected to be larger if fewer calves are slaughtered. The ratio of the number of all other nonfed cattle to the number of calves slaughtered, OCCR(I), is used in the specification. Quarterly dummy variables are used to allow for seasonal variation in NFADW(I).

NFADW(I): ONFCCR(I), D2(I), D3(I), D4(I) II-27

Nonfed beef production NFBQ(I) Nonfed beef commercial production is defined to be the product of the nonfed cattle average dressing weight, NFADW(I), and the number of nonfed cattle marketed, TNFCM(I), in a given quarter. A structural technical relation was used to approximate this relation.

NFBQ(I): NFADW(I), TNFCM(I), D2(I), D3(I), D4(I) II-28

U.S. imports of nonfed beef - world trade - and consumption relations In this study the U.S. yearly imports of nonfed beef are simultaneously determined along with the net import - net export - of other main producing or consuming regions of the world. This simultaneous solution represents the open structure of the U.S. economy and allows measuring the effect of disturbances that occur in other parts of the world on the U.S. livestock and poultry economy. The United States, under this structure, is still linked with the rest of the world through exports and imports, but the level of beef imports that in turn has an effect on domestic prices, production, and consumption is determined simultaneously with the available and needed quantities in other regions. However, by the inclusion of the U.S. nonfed beef wholesale price in this system, and by excluding prices in other foreign markets in considering the production and import decision in the U.S., the role of the U.S. as a leader in the world beef economy is maintained. This simultaneous solution for the U.S. beef import level does not imply that the decision to import is not affected by domestic factors, rather it means that the foreign markets are considered along with the main domestic factors to affect the import decision.

The demand for imports of nonfed beef, the per capita commercial civilian consumption of nonfed, and the wholesale price level of nonfed beef should be solved simultaneously. The import level of nonfed beef is affected by the current wholesale price level of nonfed beef. However, due to the recursive nature of the model used, and to the limitation of data - yearly data - regarding the foreign regions' level of production, exports, and imports of beef and veal, the U.S. yearly import level of nonfed beef is solved simultaneously with the net export - import - of the other major regions in the world beef economy. The calculated U.S. quarterly level of imports for nonfed beef is then used as a predetermined variable in estimating the per capita commercial civilian consumption of nonfed beef, NFBCN(I). This variable is used in turn as a predetermined variable in the wholesale price determination system of equations. Thus the inclusion of the current wholesale price level of nonfed beef in estimating the demand for import relationships was statistically infeasible because of the assumed recursive nature of the model used. Although using lagged price, NFBPW(L-1), is inconsistent with the standard way of estimating the demand for imports, its inclusion is justified through specification and statistical considerations.

To simplify the analysis, the world is divided into five major regions in the world beef economy, namely, Western Europe, Oceania, South America, the United States, and the rest of the world. The Western Europe region includes 17 countries, Belgium, Luxembourg, France, West Germany, Italy, Netherlands, Austria, Denmark, Finland, Greece, Ireland, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Oceania only includes Australia and New Zealand. The South American region includes eight countries, Argentina, Brazil, Chile, Colombia, Paraguay, Peru, Uruguay, and Venezuela. All countries that are excluded from the above classification are included in the rest of the world region.

Five equations were designed to represent the structural relations for the five interdependent endogenous variables, namely, NEXSA, NEXOC, NIMWE, IMPUS, and NIMRW. However, a sixth equation was needed to insure the accounting restriction for the world net import - net export - is equal to zero. The equation designed to explain the net import of the rest of the world, NIMRW, was excluded and the system became soluble with five interdependent endogenous variables and five equations. NIMRW was solved for internally in the system.

The structure of the system captures the crucial interrelationships between the most significant regions in the world beef economy and trade. The U.S. is the largest producing and consuming country of beef and veal in the world. In 1973, U.S. production accounted for 28.4 percent of world total production. Its imports accounted for 27.4 percent of world total imports in the same year. Australia is the largest exporting country in the world. In 1973, its exports of beef and veal accounted for 26.6 percent of world export. Australia is also the major exporter to the U.S. In 1974, 62 percent of total U.S. imports of beef and veal came from Australia. U.S. imports from New Zealand accounted for 18 percent of total U.S. imports of beef and veal in the same year. For that reason it was hypothesized that the decisions and factors influencing the production, consumption, and trade behavior in Oceania are likely to influence the U.S. imports level and source decision.

Western Europe is the largest importing region in the world, accounting for interregional trade. In 1973, its imports of beef and veal accounted for 54.5 percent of world total imports. In recent years, beef imports by Western Europe have dropped sharply. This drop has put increased pressure on the U.S. market, as suppliers seek to divert exports, in particular, South American suppliers. Thus as a major competitor for U.S. in the world import market for beef and veal, the interrelationships of its decisions to import along with studying the production policy and consumption behavior affecting such decisions should be considered in estimating the U.S. imports level of nonfed beef.

South America is the other most significant net exporting region, with Oceania. It is the most important supplier to Western Europe. In 1972, about 40 percent of Western Europe imports came from South America. The U.S. veterinary regulation prohibits imports of fresh, chilled, or frozen beef from this region. United States regulations require that beef imports from South America be heat-treated to 156° F for a minimum of 2 hours to assure that viruses be killed. However, the inclusion of South America in the system was due to its position in the world beef economy as the largest exporter to Western Europe - the main competitor for U.S. imports - and the pressure created by its excess supply of beef and veal on the U.S. market as it tries to divert exports.

The rest of the world region - as defined in this study - has 64 percent of the world total cattle and buffaloes, but its production counts only for a small percentage of the world total production. The significance of that region in world trade in beef stems from its potentiality as a large importing region. This will be realized as income level and living standards are improving over the years.

The five, four behavioral and one identity, yearly simultaneous equation system was specified as follows:

NEXSA(L): NEXOC(L), NIMPWE(L), IMPUS(L), NIMPRW(L), BQSA(L), T(L) II-29

NEXOC(L): NEXSA(L), NIMPWE(L), IMPUS(L), NIMPRW(L), BQOC(L),
CEOC(L), T(L) II-30

NIMPWE(L): NEXSA(L), NEXOC(L), IMPUS(L), NIMPRW(L), BQWE(L)
CEWE(L), T(L) II-31

IMPUS(L): NEXSA(L), NEXOC(L), NIMPWE(L), NIMPRW(L), NFBPW(L-1)
BQ(L-1), DYN(L), T(L) II-32

NEXSA(L) + NEXOC(L) - NIMPWE(L) - IMPUS(L) - NIMPRW(L) = 0 II-33

The favorable price for beef in the U.S. as compared to other world markets and increased beef production of major exporting regions such as Oceania and South America have been the major factors in the rise in U.S. nonfed beef imports. The rapid rise that occurred during the early sixties resulted in such concern to the beef industry that a beef import quota bill (HR-1839) was enacted (2, p. 28). As production varies cyclically with the cattle cycle, beef imports tend to fill this gap and help maintain per capita consumption at high levels. The decision to import tends to equalize the supply of low grade processing beef to be utilized with the relatively constant production of fed beef and trim from cattle feeding operations and to reduce the increase in beef prices that could be realized through excess domestic demand. This excess demand could be a sufficient reason to decrease per capita consumption and to shift consumers to other possible beef substitute products.

In this study the effect of imports level on the quarterly wholesale prices of meat is obtained through the effect of the quarterly per capita civilian consumption of nonfed beef. To transform the yearly imports level, solved for through the previous system, to quarterly figures, the average percentage of import in each quarter from the yearly level was calculated for the period 1962 through 1973. The yearly imports were then divided among the quarters according to the following:

$$\begin{aligned} \mathrm{IMPUS(I)} &= 0.221\ (\mathrm{IMPUS(L)}) && \text{for } \mathrm{I} = 1 \\ &= 0.225\ (\mathrm{IMPUS(L)}) && \text{for } \mathrm{I} = 2 \\ &= 0.300\ (\mathrm{IMPUS(L)}) && \text{for } \mathrm{I} = 3 \\ &= 0.254\ (\mathrm{IMPUS(L)}) && \text{for } \mathrm{I} = 4 \end{aligned} \qquad \mathrm{II{=}34}$$

*Nonfed beef per capita civilian consumption NFBCN(I)* Using the same assumptions and procedure used in obtaining FBCN(I), the nonfed beef per capita civilian consumption is obtained through the following identity:

$$\mathrm{NFBCN(I)} = [\mathrm{NFBQ(I)} - 0.5\ \mathrm{MBC(I)} - \mathrm{IMPUS(I)}]/\mathrm{P(I)} \qquad \mathrm{II\text{-}35}$$

*The wholesale price determination relations* The interdependency that prevails in the price determination of all close substitute meat items dictates using a different method than a single price-quantity relationship model in solving for the fed and nonfed beef prices. In this study, the prices of fed and nonfed beef are simultaneously determined with the prices of pork, broiler, and turkey as other substitute meat items. The influence of the interdependent changes in the prices of the close substitute meat items and other exogenous and predetermined variables are taken into account in this simultaneous determination of meat prices.

It is assumed in this study that the simultaneous determination of those meat prices takes place at the wholesale market level. The question of where the price of meat items is actually determined is still empirically unsolved. The usefulness of the microeconomic theory of demand as a guide for the sign and magnitude of a priori expectations in price-quantity analysis holds when this analysis is carried out in the retail - consumer - market level. The solution of prices at the wholesale level involves the process transformation of the retail prices through margin equations. This solution involves matrices inversion and transformation that usually results in destroying the usefulness of the consumer theory of demand in setting theoretical expectations on the sign and magnitude of the price, quantity, and income relations. It was proved, through earlier work in this study, that the published wholesale meat prices are more reliable and consistent to use in explaining the variations in farm prices. Farm prices are crucial to the structure of this study since they are assumed to be used by farmers either directly or through the consideration of the cattle finishing profitability indicator, CFPI, as decision variable affecting their level of production. Also, the variations in the level of the U.S. nonfed beef imports were significantly explained by the variation in the nonfed beef wholesale price, rather than retail prices. Those factors supported the decision to estimate meat prices at the wholesale market level. However, it has to be recognized that deviation of the specification of the upcoming simultaneous system from the conventional microeconomic consumer demand theory is the reason for referring to it as a price determination system rather than a demand system.

The exogenous and predetermined variables included in the system were chosen according to economic, logical, and statistical criteria. The per capita consumption of fed and nonfed beef are included as predetermined variables. The per capita consumption variables for pork, broiler, and turkey were treated in this stage as exogenous variables. The deflated per capita consumer disposable income was included to explain variations in the meat item prices. By including this income variable as an exogenous variable an assumption is made, namely, that income influences prices but not vice versa. That is, any one meat item is typically a very small part of the economy, and thus makes a small contribution to income. The use of deflated income to explain the nondeflated prices is stemmed from statistical difficulty in using nominal income data. However, the analysis of the effect of real income on prices of meat items and on the rest of the sector may have a useful application to decision makers in the economy. The distribution of such income also affects prices. Thus, the unemployment rate, UNEMP(I), was used to indicate the distribution of consumer units receiving purchasing power (30). The inclusion of the consumer price index, CPI(I), as a separate explanatory variable is to eliminate the effect of the change in general price level and to determine if real correlation exists among prices of the individual meat items. The inclusion of CPI(I) as a separate explanatory variable and as a deflater for the consumer per capita disposable income variable implied that the effect of inflation on prices is nonlinear in nature. This hypothesis is not empirically verified in this study, and the problem of nonlinearity was ignored in the statistical estimation process. Since there is no standard technique for deflation which is applicable to all problems (54), the judgment on the usefulness of the procedure used is left to the power of explaining the variations in prices and to the accuracy of the prediction results from such specification. It is conventional to use a linear time trend variable as a common proxy variable to account for changes in tastes and preferences. This variable was excluded from the final specification due to statistical problems. The change in population also has a direct influence on demand and prices. To isolate the change in population effect from the desired price-quantity relationship investigated, the quantity and income variables in this system are used on a per capita basis.

The structural relations for the interdependent simultaneous wholesale price determination system for fed beef, nonfed beef, pork, broiler, and turkey were specified as follows:

FBPW(I): NFBPW(I), PPW(I), BRPW(I), TRPW(I), FBCN(I), DYND(I-1),
UNEMP(I), CPI(I), D2(I), D3(I), D4(I) II-36

NFBPW(I): FBPW(I), PPW(I), BRPW(I), TRPW(I), NFBCN(I), DYND(I-1),
UNEMP(I), CPI(I), D2(I), D3(I), D4(I) II-37

PPW(I): FBPW(I), NFBPW(I), BRPW(I), TRPW(I), PCN(I), DYND(I-1),
UNEMP(I), CPI(I), D2(I), D3(I), D4(I) II-38

BRPW(I): FBPW(I), NFBPW(I), PPW(I), TRPW(I), BRCN(I), DYND(I-1),
UNEMP(L), CPI(I), D2(I), D3(I), D4(I) II-39

TRPW(I): FBPW(I), NFBPW(I), PPW(I), BRPW(I), TRCN(I), DYND(I-1),
UNEMP(I-1), CPI(I), D2(I), D3(I), D4(I) II-40

The inclusion of seasonal dummy variables to allow for changes in the level of meat items prices is based on statistical significance using F-test of homogeneity.

Farm price determination relations The differences between the wholesale beef prices, FBPW(I), and the choice slaughter steer prices, CSP(I), and between the wholesale dressed meat prices of cow beef, NFBPW(I), and utility cow liveweight prices, CUP(I), are clearly a problem of margin and price spread not of price differences due to quality or space or time. Thus, this block of equations is usually referred to as the margin equations.

The farm prices are obtained by subtracting the per unit cost - prices - of all marketing components from the wholesale prices. Assuming that the supply function of the marketing services is perfectly elastic, horizontal, the margin remains constant as the demand for services - associated with increasing volume - increases (39). The same marketing margin is subtracted from the wholesale prices at all levels of quantity, and hence the derived farm demand function is parallel to the assumed wholesale function as they are represented by a linear functional form. When farm prices decrease, they tend to become a smaller percentage of the wholesale price.

Marketing margin is represented by two factors, the food marketing distribution wage, FMW(I), and the cattle by-product value, CBYP(I). An increase in the costs of providing existing marketing service that is embodied in the final meat item will cause a decline in the derived farm demand and the wholesale supply with a consequent decrease in farm prices. Thus, FMW(I) is expected to be negatively correlated with the farm prices of CSP(I) and CUP(I).

Cattle by-products include everything left after recovering the primary skeleton and its covering of edible tissue from the slaughtered animal. It accounts for about 40 percent of the liveweight of the cattle. The value of by-products usually covers slaughtering costs. However, with a high variability in the combined value of all by-products, this does not always occur (2). The higher the value of by-products, the higher are the prices farmers are expected to receive for their animals from packers. Thus, the value of the by-product, CBYP(I), is expected to be positively associated with the farm prices of cattle.

The structural relations used in this study to estimate steer prices, cow prices, and feeder steer prices are as follows:

Steer prices relation CSP(I)

CSP(I): FBPW(I), FMW(I), CBYP(I), D2, D3, D4 II-41

Cow prices relation CUP(I)

CUP(I): NFBPW(I), FMW(I), CBYP(I), D2, D3, D4 II-42

Feeder steer prices relation CFSP(I)

CFSP(I): CSP(I), CFPI(I-1), T(I), D2, D3, D4 II-43

The general level of feeder prices is derived from finished steer price levels. The feeding profitability indicator is also used in this specification. The level of prices in the three equations is allowed to change between quarters through the inclusion of the seasonal quarterly dummy variables.

# CHAPTER III. THE ESTIMATED STRUCTURE OF THE FED AND NONFED CATTLE-BEEF SECTOR'S MODEL

## Introduction

The problem to be analyzed in this study is defined in the first chapter. Chapter II was devoted to the formulation of the economic model that is oriented toward solving the first main objective of the study. This chapter is devoted to the discussion of the statistical methods and techniques considered and used in estimating the coefficients which relate the variables in the model, and reporting the estimated structure of the model. In reviewing the statistical methods used, the full mathematical proofs are excluded. References are made at points where such proofs or mathematical derivation are needed. The second section of this chapter is devoted to the discussion of the statistical methods used. The estimated structure is reported in the next section, and the last section is devoted to interpretations and evaluation of results.

## Statistical Considerations

### General regression techniques

The regression equation model postulates a causal relationship between a dependent variable and one or more independent or explanatory variables. A variable is called dependent because it is supposed to be functionally dependent on other variables. The regression model attempts to explain observed changes in a dependent variable as being caused by changes in the independent variables. Conceptually, the changes in the independent variables are observed independently of the causal relation expressed by the model.

An explicit functional form widely used to express the causal relation between a dependent and independent variable is the linear form. Even if the relation is not linear, when the relevant range of operation is small, the linear form may adequately represent the true functional form. If a linear relation exists between a dependent variable Y and P independent variables $X_1$, $X_2$, -- $X_p$, a linear model of the following form is assumed for a sample of n observations.

$$Y_i = B_0 + B_1X_{1i} + B_2X_{2i} + \ldots + B_pX_{pi} + U_i \quad i = 1, \ldots, n \qquad \text{III-1}$$

The same model could be expressed in matrix notations as follows

$$Y = XB + U \qquad \text{III-2}$$

where

Y is a (n x 1) column vector of observations $Y_1$, ... $Y_n$

X is a (n x P + 1) matrix of known form

B is a (P + 1 x 1) vector of unknown parameters

U is a (n x 1) vector of unknown errors

To estimate the vector of the unknown parameters, B, some assumptions have to be made regarding how the observations in this equation were generated. These assumptions are crucial to the estimation process (19, p. 121).

1. $E(U) = 0$ III-3
2. $E(U'U) = \sigma^2 I$ III-4
3. X is a set of fixed numbers $[E(U'X) = 0]$ III-5
4. X has a rank $P + 1 < n$ III-6

A complete explanation of the meaning of these assumptions is provided in many texts (3, 19, 38). However, in short, assumption III-4 indicates that the $U_i$ values are pairwise uncorrelated with constant variance $\sigma^2$ and zero covariance elements, assumption III-5 states that in repeating sampling, the sole variation in the Y vector is variation in the U vector and the properties of the estimates and tests are conditional upon X. Assumption III-6 states that the X matrix should be full rank and the columns of X should be linear independent from each other.

The most widely used method of estimation to obtain the estimates of those unknown parameters - given this previous set of assumptions - is the Ordinary Least Squares Method (O.L.S.). The O.L.S. estimates for the vector B, b, are obtained through minimizing the sum of squares of the residuals. The normal equation used to obtain such estimates is $b = (X'X)^{-1}X'Y$. The variance of this estimated vector will be given by $V(b) = \sigma^2(X'X)^{-1}$. The derivation of those results along with the properties of the estimator vector b is discussed in many texts (1, p. 75; 19, p. 123; 38, p. 111).

### The use of summary statistics

Computation of summary statistics to asses the usefulness of the estimates in any applied econometric study is always done. A complete discussion for the procedure used to test the significance of a set of coefficients, a single coefficient, and the test for a hypothesis that one model is not an improvement over the other are given in (19, 20, 38) and they are not repeated here.

#### The coefficient of multiple determination $R^2$

The coefficient of multiple determination $R^2$, a square of the coefficient of multiple correlation R, is used along with every equation in this study. In linear regression estimation, the residuals indicate the extent of the movement in the dependent variable that is not explained by the independent variables. If the residuals are small relative to the total movement in the dependent variable, then it follows that a major part of the movement has been accounted for. Accordingly $R^2$ is defined to measure the extent of movement or variations in the dependent variable that is explained by the independent variables. That is

$$R^2 = \frac{\text{variation explained by the regression equation}}{\text{total variation of the dependent variables}} =$$

$$\frac{\text{sum of squares due to Reg.}/B_0}{\text{total(corrected)sum of squares}} = \frac{b'X'Y - n\bar{Y}^2}{Y'Y - n\bar{Y}^2}$$

$R^2 = 1$ if $\hat{Y} = Y$, indicating the prediction is perfect. $R^2 = 0$ if $\hat{Y}_i = \bar{Y}$ that is $b_1 = \ldots = b_p = 0$. However $R^2$ should not be used as a measurement of goodness of fit of the causal relation. It can be used for comparison of the relative performance of two competing regressions only when the dependent variables are the same and the number of X's are the same in the equations being compared. This last condition was set because by adding additional variables in the regression equation, the sum of squares of the residual necessarily decreases, thus $R^2$ necessarily increases. This is a mathematical property and does not depend on the relevance of the added variable to the causal relation.

Standard error of regression S.E. In adding an extra explanatory variable to a regression equation the summary statistics $R^2$ must increase. However, this will impose an extra condition on the residual. To decide if the reduction in the residual sum of squares is worth the "price" of the extra constraint a summary statistics, residual variance, is computed.

$$V(U_t) = \frac{\sum_{t=1}^{n} \hat{U}_t^2}{d}$$

and the estimate is $S_u^2 = \frac{\sum_{t=1}^{n} \hat{U}_t^2}{n-p}$

where $S_u^2$ is an estimate of the assumed constant variance of the disturbances (39, p. 341), and measures the variability of the observed Y about the computed regression line. The standard error (S.E.) of estimate is the square root of the variance of regression. S.E. provides a measure of variability in the same units of measure as the dependent variable.

The regression which yields the smallest S.E. is not necessarily always desirable. In a regression equation the decision on including or excluding a variable is based on theoretical considerations and the use to which the regression is put, rather than on mere maximization of $R^2$ or $\bar{R}^2$.[1] When the objective is prediction, the smaller S.E. is desirable. But when the objective is testing a null hypothesis based on the regression estimates and not prediction, the researcher is interested then in unbiased estimates of the parameters. Unbiased estimates may be obtained by including all the theoretical specified variables in a regression equation irrespective of what they do to the summary statistic S.E. (31, p. 20).

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[1] $\bar{R}^2 = 1 - (1 - R^2)\frac{(n-1)}{n-p}$ is a summary statistics analogous to $R^2$ and based on the residual variance, i.e., $\bar{R}^2 = 1 - V(e)/V(Y)$ and since it includes d.f. as well as sum of squares for residual, thus it does not have to always increase by including any extra variable. There is one-to-one correspondence between the $\bar{R}^2$ and the variance of the residual V(e).

### Violations of O.L.S. assumptions

In all statistical applications, the power of the O.L.S. method depends on the underlying assumptions being fulfilled for a particular application in question (19, p. 159). If one or more of those assumptions are not fulfilled, alternative estimation procedure has to be used. In this section a consequence expected from nonfulfillment of various assumptions, tests for whether the assumption is fulfilled or not, and alternative statistical methods to employ when the classical O.L.S. model is inappropriate are discussed.

Multicollinearity Assumption III-6 stated that there exists no linear dependence between the explanatory variables, i.e., X matrix has rank $P + 1 < n$ (full rank). The problem of multicollinearity exists when interdependence is present between any of the explanation variables. When some or all of the explanatory variables are perfectly collinear, extreme multicollinearity, the $(X'X)$ matrix will become singular, which means mathematically that the inverse $(X'X)^{-1}$ does not exist. This in turn means that the O.L.S. estimates do not exist. The problem of perfect correlation seldom occurs in real applied studies, but it is usual to see explanatory variables that are highly correlated. This will lead to inflating the $(X'X)$ matrix and to greater standard errors. The presence of multicollinearity also results in obtaining less precise estimates for the parameters, and obtaining unexpected coefficient signs that disagree with the theoretical expectations. With the presence of multicollinearity, the estimates will be highly dependent on the observation sample period thus providing less accurate prediction. The tests for the presence of multicollinearity and the methods used to reduce or eliminate its effect are discussed in many texts (1, p. 92; 19, p. 159; 38, p. 181).

Autocorrelation Assumption III-4 stated that serial independence should exist among the disturbance term. The problem of serial correlation presence among the residuals is called autocorrelation. Specifying the incorrect form of the relation between variables will result in violating assumption III-4, i.e., using linear form when quadratic form is the correct one. The influence of any omitted variable, that may have some influence in explaining the relation, from the specification of the causal relation is represented in the residual and will cause autocorrelation among those residuals. The measured error in the explained variable is another source of the presence of autocorrelation.

Given that the original model is

$$Y_t = A + BX_t + U_t \qquad \text{III-8}$$

and if assuming that first order autoregressive scheme exists between the disturbances term

$$U_t = \rho\, U_{t-1} + e_t \qquad |\rho| < 1 \qquad \text{III-9}$$

where $e_t$ satisfies the following assumptions

$$E(e_t) = 0$$

$$E(e_t\, e_{t+s}) = 0 \qquad s \neq 0 \text{ for all } t$$

$$E(e_t\, e_{t+s}) = \sigma_e^2 \qquad s = 0 \text{ for all } t$$

This indicates that the e's are uncorrelated random variables with mean zero and variance $\sigma_e^2$. Johnston (19) has shown that the above concludes to

$$E(U_t\, U_{t-1}) = \rho\, \sigma_u^2$$

and in general

$$E(U_t\ U_{t-s}) = \rho^s \sigma_u^2$$

Thus this model does not satisfy the assumption of independency among the residuals. The consequences of using the O.L.S. method or formula in estimating the unknown parameter of this model are discussed in many texts (1, p. 131; 19, p. 246; 38, p. 160).

Test against autocorrelation To test for the presence of autocorrelation, Durbin-Watson statistics were used in this study. For checking against the presence of autocorrelation in any time series regression, a null hypothesis stating that randomness exists between the successive disturbances - positive autocorrelation = 0 - is tested against an alternative hypothesis stating that positive autocorrelation exists among them. Assuming that $\hat{U}_1, \ldots, \hat{U}_n$ are satisfactory approximations of the corresponding residuals, then the Durbin-Watson statistic (D.W.) is given by

$$\text{D.W.} = d = \frac{\sum_{I=2}^{n} (U_I - U_{I-1})^2}{\sum_{I=1}^{n} U_I^2}$$

To avoid complication in the application procedures, Durbin and Watson (1950-1951) formulated $(d_L, d_u)$ bounds for each limit lies in this interval whatever X may be. The procedure used is to reject the previous null hypothesis if $d < d_L$, if $d_u > d > d_L$ no conclusion is drawn, and the null hypothesis is rejected if $d > d_u$. There are published tables containing those limits with certain numbers of observations and certain numbers of variables. Another well known procedure for testing against autocorrelation is the Von Neumann ratio (38). However, given that it is closely related to D.W. statistics, and that D.W. is computed directly in the computer program used for this study, the latter was only used in this analysis.

The transformed model In this study, the presence of autocorrelation among the residuals in every equation stated in the model was investigated. Whenever D.W. indicates the rejection of the hypothesis of randomness between disturbances, the next model was used. It was shown by Theil (38) that if T is defined as the transformation matrix where the transformed variables indicated by T are

$$TY = \sqrt{(1 - \rho^2)}\ Y_i \qquad \text{for } i = 1$$

$$= Y_i - \rho Y_{i-1} \qquad \text{for } i = 2, \ldots n$$

$$TX = \sqrt{(1 - \rho^2)}\ X_i \qquad \text{for } i = 1$$

$$= X_i - \rho X_{i-1} \qquad \text{for } i = 2, \ldots n$$

These results are obtained by substituting III-8 in III-9. Thus the transformed model is

$$TY = TXB + TU$$

Then applying the O.L.S. method to estimate the coefficient vector, B, using the transformed variables will result in

$$b = (X'T'TX)^{-1}\ X'T'TY$$

This method is called Generalized Least Squares Method (G.L.S.) for solving for a linear model with autocorrelation. The above estimator is the best linear unbiased estimate for the vector B (3, 19, 38).

Lagged dependent variable model

The specification of some of the equations in this model was completed by the inclusion of the lagged dependent variable as an explanatory variable. In general such a model could be stated as follows:

$$Y_t = B_0 + B_1 X_t + B_2 Y_{t-1} + U_t$$

$$U_t = \rho U_{t-1} + e_t \qquad |\rho| < 1$$

In this model it is always true that $Y_{t-1}$ and $U_t$ are correlated. Since this would violate assumption III-5, the O.L.S. estimates for the B's are not consistent. The method of instrumental variables is appropriate for solving such a model (19, p. 278). The variable $X_{t-1}$ is correlated with $Y_{t-1}$ and by assumption the errors are independent of $X_{t-s}$ for all s. Therefore, $X_{t-1}$ can be used as an instrumental variable. The procedure, in short, used to solve for the parameters of this model in the study is

1. Obtain initial estimates for B's by instrumental variable
   a. Regress $Y_{t-1}$ on 1, $X_t$, $X_{t-1}$
      Calculate $\hat{Y}_{t-1}$ from the regression in a
   b. Regress $Y_t$ on 1, $X_t$ and $\hat{Y}_{t-1}$
      Estimates obtained are denoted $\hat{B}_0$, $\hat{B}_1$, $\hat{B}_2$
2. Obtain a consistent estimator for $\rho$
   a. Calculate the residuals
      $\hat{U}_t = Y_t - \hat{B}_0 - \hat{B}_1 X_t - \hat{B}_2 Y_{t-1}$
   b. Use these residuals to estimate $\rho$

$$\rho = \frac{\sum_{t=2}^{n} \hat{U}_t \hat{U}_{t-1}}{\sum_{t=2}^{n} \hat{U}_{t-1}^2}$$

3. Obtain final estimates for the parameters from the regression

$$Y_t - \hat{\rho}Y_{t-1} = (1 - \hat{\rho})B_0 + (X_t - \hat{\rho}X_{t-1})B_1 + (Y_{t-1} - \hat{\rho}Y_{t-2})B_2$$
$$+\hat{U}_{t-1}(\rho - \hat{\rho}) + \text{remainder} \qquad t > 3, 4, \ldots n$$

and the final estimates obtained are

$\tilde{B}_0$, $\tilde{B}_1$, $\tilde{B}_2$ and $\hat{\rho} + (R - \hat{\rho}) = \rho$

It has to be noticed that when the specification of a regression is dynamic in nature, the trend components in the dependent variable are being explained by the equation. A conceptual error of specification arises if the trend component is eliminated from this series, i.e., equation II-1.

<u>The use of dummy variables</u>

Without a priori information regarding the nature of the data, it is customary to assume that the specified equation is the same for all observations. In some situations this assumption may seem to be restrictive. In such cases, it can be relaxed somewhat through the use of dummy variables technique. This allows for separating information on certain variables into discrete categories by assuming dummy values of (0, 1) for each of the categories. Dummy variable techniques can be used for identifying qualitative differences, scanning, as jackknife, seasonal pattern, and temporal effect (31, p. 88).

In this study, dummy variables of the form (0, 1) are used for the allowance for temporal effect, i.e., to allow for changes among levels and/or slopes between quarters. In some of the equations used in this study it was believed that observations within specific quarters have the same parameter values, and observations in different quarters may have different sets of parameters. In such case, it is hard to set up continuous scale for the variable. Some levels have to be assigned to those variables in order to take account of the fact that various variables may have separate deterministic effects on the response. The dummy variables used in the quarterly equation that would allow for changes in the level of the regression between quarters were constructed as follows:

| | D2 | D3 | D4 |
|---|---|---|---|
| 1st quarter | 0 | 0 | 0 |
| 2nd quarter | 1 | 0 | 0 |
| 3rd quarter | 0 | 1 | 0 |
| 4th quarter | 0 | 0 | 1 |

The interpretation of the parameters of those variables and the level of the regression equation for each quarter are discussed in (20, p. 54; 30, p. 28; 31, p. 104).

Dummy variables are used also to allow for changes in the rate of effect of one explanatory variable on the response among quarters. Assuming that the variable believed to have distinguished parameter or effect on the dependent variable is identified - X - to allow the separation of the effect among quarters, dummy variables of the following form are used.

| | X | X.D2 | X.D3 | X.D4 |
|---|---|---|---|---|
| 1st quarter | X | 0 | 0 | 0 |
| 2nd quarter | X | X | 0 | 0 |
| 3rd quarter | X | 0 | X | 0 |
| 4th quarter | X | 0 | 0 | X |

The interpretations of the parameters of those dummy variables are discussed in many other studies (19, 20, 30), where the advantages of using dummy variables in regression analysis are discussed in (31, 38).

In this study, the interest is to isolate the causal effect of one variable on another and not to merely relate the comovements of one series with another. When all or some variables move in the same direction because of general economic activity, the resulting relation may well be spurious. When such economic activity is a smooth function of time, the series is said to contain a trend component because although there is variation, the series is generally moving in one direction steadily over the time period. Whenever it was felt that "trend" in the time series data underlies a spurious relation in the specific regression equation, then time - T(I) or T(L) - as an explicit variable was introduced in this equation to abstract from this influence. The definitions of T(I) and T(L) are given in Chapter II.

System methods

In many applied econometric analyses, the single equation structure and methods of estimation like O.L.S. will suffer because the true structure of the model is more complicated. Even if the interest centers upon a single equation, an explicit account of the system of relations in which this equation is embedded should be taken. The previously discussed methods of estimation, namely O.L.S. and G.L.S., could be used in estimating system of equations given certain restrictions upon the parameters considering the following model.

Given that the model contains M endogenous variables, K predetermined variables (exogenous and lagged endogenous), and the model is described by M equations; given that N observations on the variables are available, the M structural equations are written

$$YT = XB + U$$

where Y is (N x M) matrix of observations on the endogenous variables
X is (N x K) matrix of observations on the predetermined variables
T is (M x M) matrix of coefficient of the endogenous variables
B is (K x M) matrix of coefficient of the predetermined variables
U is (N x M) matrix of error

The T matrix is nonsingular and it could be expressed having 1's in the diagonal.

The mth structural equation is stated as

$$YT_m = XB_m + U_m \qquad m - 1, \dots M$$

Suppose that M* endogenous variables enter this equation, and M** do not enter the equation where M* + M** = M. Further, assume that K* denotes the number of predetermined variables in the equation and K** predetermined variables do not enter the mth structural equation where K* + K** = K. The problem of identification is the problem of whether the model is restrictive enough so that, given sufficiently large samples, the values of parameters can be determined. This issue is important and is in a sense logically prior to the issue of statistical estimation. Using the order condition for identifiability, in short, the mth equation is said to be over identified, just identified, or unidentified if K** are greater than, equal, or less than M*-1 respectively.

Depending upon the structure and assumptions used for any single model, O.L.S. could be verified as an acceptable procedure for solving for equations in the system or not. In the system of simultaneous nature, if O.L.S. method is applied to an equation containing more than one current endogenous variable in the relation, and which ever variable one selects as the dependent variable, the remaining endogenous variables will generally be correlated with the disturbance in the equation. Thus assumption III-5 is violated, and O.L.S. estimates will be biased and inconsistent.

From the estimation viewpoint the simplest of all simultaneous equation systems are the recursive systems. The recursive system is characterized by a triangular T matrix and a diagnonal variance-covariance matrix for the disturbance vector U(38, p. 369). If those characteristics prevail in a system, then O.L.S. or G.L.S. methods could be utilized for solving for the parameters of each equation in the model. The model constructed in this study is recursive in nature except for two blocks of five equations each where simultaneity is considered between the interdependent endogenous variables. Methods of estimation for simultaneous systems are either single-equation methods, or a complete system method, which is applied to the system as a whole (38, p. 376).

The method used in solving for those two simultaneous blocks is the three stage least square method (3SLS) which takes account for all the equations in a model. The mth equation could be written as

$$y_m = Y_m B_m + X_m \delta_m + U_m \qquad m = 1, \ldots M$$

where $y_m$ = (n x 1) vector of sample obervations on the dependent variable in the mth equation

$Y_m$ = (n x $m_i$) matrix of observations on the other endogenous variables in the equation

$X_m$ = (n x $K_i$) matrix of observations on the predetermined variables in the equation

$B_m$ and $\delta_m$ are vectors of parameters and $U_m$ is disturbances

Let $Z_m = [Y_m \; X_m]$ and $d_m = \begin{bmatrix} B_m \\ \delta_m \end{bmatrix}$

Then $$y_m = Z_m d_m + U_m \qquad m = 1, \ldots M \qquad \text{III-10}$$

Premultiply both sides by X', where X is the (N x K) matrix of predetermined variables in the model

$$X'y_m = X'Z_m d_m + X'U_m \qquad m - 1, \ldots M \qquad \text{III-11}$$

The variance-covariance matrix of the disturbance is

$$E(X'U_m \; U_m'X) = \sigma_{mm} \; X'X$$

Thus the vector $d_m$ should be estimated by G.L.S.

$$\hat{d}_m = [Z_m' \; X(X'X)^{-1}X'Z_m]^{-1} \; Z_m' \; X(X'X)^{-1}X'y_m \qquad \text{III-12}$$

which is equivalent to 2SLS estimator by substituting for Z. The variance-covariance matrix of III-11 is written as

$$V = \begin{bmatrix} \sigma_{11}X'X & \sigma_{12}X'X & \ldots \; \sigma_{1M} \; X'X \\ \sigma_{21}X'X & \sigma_{22}X'X & \ldots \\ \\ \sigma_{M1}X'X & \sigma_{M2}X'X & \ldots \; \sigma_{MM} \; X'X \end{bmatrix}$$

where $\sigma_{mj}$ denotes the contemporaneous covariance of the structural disturbances of the mth and jth equation. Collecting the $\sigma_{mj}$ in a matrix $\Sigma$

$$V = \Sigma * (X'X)$$

$$V^{-1} = \Sigma^{-1} * (X'X)^{-1}$$

The 2SLS estimator calculated for each structural equation from III-10 to yield calculated vector $\hat{U}_m (m = 1, \ldots M)$ from which estimates $S_{mj}$ of the $\sigma_{mj}$ computed. Thus the 3SLS estimator d is then given by

$$d = \left[ \begin{bmatrix} Z_1X & 0 & \ldots & 0 \\ 0 & Z_2X & \ldots & 0 \\ 0 & 0 & & Z_mX \end{bmatrix} \begin{bmatrix} S_{11}(X'X)^{-1} & S_{12}(X'X)^{-1} & \ldots & S_{1M}(X'X)^{-1} \\ & & & \\ S_{M1}(X'X)^{-1} & S_{M2}(X'X)^{-1} & \ldots & S_{MM}(X'X)^{-1} \end{bmatrix} \begin{bmatrix} X'Z_1 & 0 & 0 \\ 0 & X'Z_2 & \\ 0 & & X'Z_m \end{bmatrix} \right]^{-1}$$

$$\begin{bmatrix} Z_1'X & 0 & \ldots & 0 \\ 0 & Z_2'X & \ldots & 0 \\ 0 & 0 & \ldots & Z_M'X \end{bmatrix} \begin{bmatrix} S_{11}(X'X)^{-1} & S_{12}(X'X)^{-1} & S_{1M}(X'X)^{-1} \\ & & \\ S_{M1}(X'X)^{-1} & S_{M2}(X'X)^{-1} & S_{MM}(X'X)^{-1} \end{bmatrix} \begin{bmatrix} X'Y_1 \\ \\ X'Y_M \end{bmatrix}$$

Notice that III-12 is Aitken estimator (38, p. 451). This 3SLS estimator provides no gain when the disturbance covariance matrix $\Sigma$ is diagonal or when the structural equations are just identified (38, p. 511). If the last condition holds, the vector equation in III-11 consists of as many equations as there are d elements to be estimated; the estimator $d_j$ is obviously $(X'Z_{jm})^{-1}X'y_m$, the 2SLS estimator in the just identified case.

Since each of the structural equations in the wholesale price system of equations is just identified, thus although the 3SLS estimator procedure was attempted to take account of all equations in the system it became a two stage Aitken estimator. The 3SLS estimation procedure provides an asymptotic gain over 2SLS in estimating the five equation system of world trade since all equations are over identified. The covariance condition for use in the system estimation procedure was assumed to hold, and no attempt was made to verify the existence of this condition.

## The Estimated Structure

In this section, the results of the statistical estimation for the model discussed in the previous chapter are presented. The statistical methods and considerations discussed in the previous section were used as tools to obtain and apraise the statistical results presented below. Several summary statistics are presented along with every estimated equation. The coefficient of multiple determination $R^2$, F test statistics, the standard error of the residual S.E., and the Durbin-Watson statistics D.W. are given directly under each of the estimated equations. The presence of $\hat{\rho}$ along with those summary statistics indicates that D.W. statistic for the original equation implied the presence of significant autocorrelation among the residuals, thus G.L.S. method is used through the use of transformed variables. The inclusion of dummy variables in an equation to allow shifts in either the level of the intercept or in the slope indicates that the use of this model was proved, through F test of homogeneity, to be an improvement over other model with no dummy variables. The t value used for testing for the significance of each estimated coefficient is presented in parentheses directly under the coefficient. Since the majority of the estimated coefficient are significantly different than zero at either .05 or .01 level of significance, for the appropriate degrees of freedom, the sign (*) is only used to distinguish those coefficients that are not significant at either of those levels.

The sample period of 1953 to 1974 was used to estimate all yearly inventory structural equations. The quarterly structural equations were all estimated with a 1963-1973 sample period. The world trade section was estimated using yearly observation for the 1960 to 1973 sample period. The equations are numbered according to the presentation in Chapter II.

<u>The inventory equations</u>

$$
\begin{aligned}
1.\quad \text{CBCS}(L) = {} & \underset{(3.039)}{100.6328}\quad \text{CFSP4}(L-2) + \underset{(1.023)^*}{31.7164}\ \$\ \text{CFSP4}(L-1) \\
& + \underset{(25.678)}{0.9382}\quad \text{CBCS}(L-1)
\end{aligned}
$$

$R^2 = 0.9968$ S.E. $= 530.69$ D.W. $= 1.5703$ $\hat{\rho} = 0.7669$

$F = 1315.7$

If the producers would experience a 1 dollar increase in the feeder steer prices in the fourth quarter 2 years ago, they will tend, due to time lag in production, to increase CBCS(L) by 101,000 head this year. The number of CBCS is highly related from one year to another and differ in large measure according to the level of CFSP4(L-2) and to the phase of the cattle cycle which is captured in part by $ CFSP4(L-1).

$$2.\quad CDCS(L) = \underset{(4.892)}{-443.7798}\ CUP4(L-1) + \underset{(4.12)}{14167.04}\ MFPR(L-1)$$

$$\underset{(3.844)}{-1.9259}\ PMC(L-1) + \underset{(8.094)}{26.7651}\ MCN(L-1)$$

$$R^2 = 0.9948 \quad S.E. = 1299.4 \quad D.W. = 1.6816 \quad F = 864.49$$

If CUP4(L-1) increased by 1 dollar per cwt, the dairy cows and heifers on farms January 1 of next year will tend to decrease by 443.8 thousand head. As the production of milk per cow PMC(L-1) increases by 1 pound the producers would get the same amount needed according to the market situation from fewer cows and tend accordingly to decrease the CDCS(L) by 1.93 thousand head as of January 1. The increase in the per capita human consumption of milk equivalent lagged one year, MCN(L-1), would have a strong impact on increasing the number of CDCS(L). The increase in MFPR(L-1) would tend to make dairy production a profitable operation, thus farmers would tend accordingly to keep more dairy cows and heifers on farms for that purpose.

$$3.\quad CCVS(L) = -7432.6672 + \underset{(5.514)}{0.6511}\ CTCS(L-1)$$

$$+\underset{(3.183)}{103.243}\ CFSP4(L-1)$$

$$R^2 = 0.9833 \quad S.E. = 711.46 \quad D.W. = 0.9784 \quad \hat{\rho} = 0.8458$$

$$F = 372.98$$

As the CTCS(L-1) increase by 1,000 head, CCVS(L) will tend to increase by 651 head. This is a physical relationship. The increase of $1 per cwt in CFSP4(L-1) has a greater effect and CCVS(L) would tend to increase by about 103 thousand head as in January 1.

4. $$CSTS(L) = 511.7457 \underset{(5.73)}{+0.4342} \; CCVS(L-1) \underset{(2.717)}{+65.009} \; CFSP4(L-1)$$

$$R^2 = 0.9902 \quad S.E. = 506.31 \quad D.W. = 1.8063 \quad \hat{\rho} = 0.6862$$

$$F = 642.29$$

If CCVS(L-1) increases by 1,000 head, 434 head would appear in next years January 1 inventory as CSTS(L). Again the $1/cwt increase in CFSP4(L-1) will cause the number of CSTS(L) to increase by about 65 thousand head.

5. $$BULS(L) = 1342.7221 \underset{(2.132)}{+0.03482} \; CBCS(L-1) \underset{(1.173)^{*}}{-18.9793} \; T(L)$$

$$R^2 = 0.99 \quad S.E. = 55.446 \quad D.W. = 0.918 \quad \hat{\rho} = 0.8149$$

$$F = 498.28$$

The variable CBCS(L-1) was used to approximate CDCS(L-1) which turned out to be insignificant and always associated with a priori unexpected sign of coefficient. BULS(L) are decreasing over time as indicated by the negative large coefficient associated with the yearly trend variable.

6. $$CHTS(L) = 8343.6507 \underset{(3.873)}{+0.1445} \; CCVC(L-1) \underset{(5.904)}{+68.4987} \; CFSP4(L-1) \underset{(4.131)}{-54.8916} \; \$ \, CFSP4(L-1)$$

$$R^2 = 0.9988 \quad S.E. = 246.63 \quad D.W. = 1.2125 \quad \hat{\rho} = 0.6374$$

$$F = 3829.0$$

The equation explains the physical relationship between the total heifers 500 lb and over and the calf crop during the previous calendar year. If calf crop increased by 1,000 head during the previous year, about 145 head of them will be classified as heifers 500 lb and over by the beginning of the next year.

7. TCCE(L) = CBCS(L) + CDCS(L) + CCVS(L) + CSTS(L) + BULS(L)
+ CHTS(L)

This variable is obtained through the summation of the previous six categories of cattle and calves on farms January 1 of the given year. TCCE(L) is used later in the balance accounting procedure.

8. CCVC(L) = 0.7991 CTCS(L) +208.0291 CFSP4(L-1)
(33.023) (5.630)

$R^2$ = 0.9989 S.E. = 1497.6 D.W. = 1.6186 F = 9223.4

The intercept term was not used in this specification since inclusion through time by holding the number of CTCS(L) equal to zero will be absolutely no calf crop. The calving rate estimated through this equation is about 80 percent which is a little lower than the published rate for the past several years. As the CFSP4(L-1) increases by $1 per cwt, the producers would keep cows and heifers to produce more calves and hence CCVC(L) would tend to increase by 208 thousand head.

9. TCCA(L) = TCCA(L-1) + CCVC(L-1) + NIMPL(L-1) - FCM(L-1)
- TNFCM(L-1) - DLOSD(L-1)

The total number of cattle and calves on farms at January 1 in year (L) estimated through the estimated inventory equation (TCCE(L)) is then adjusted by a scaler K to coincide with TCCA(L) which implies the balancing of the model for one year to another.

TCCA(L)/TCCE(L) = K(L)

The components of TCCE(L) are adjusted accordingly at this point by the scaler K(L). The adjusted inventory variable will be used as predetermined variables in the rest of the model.

$$\begin{array}{llllll} 10. & \text{CHRS(L)} = -746.9711 & + 0.1796 & \text{CBCS(L)} & + 0.1012 & \\ & & (34.448) & & (3.525) & \\ & & \$\ \text{CBCS(L)} & + 16.2581 & \text{CFSP4(L-1)} & \\ & & & (4.3398) & & \end{array}$$

$R^2 = 0.9997$ S.E. = 100.44 D.W. = 1.8204 F = 16606.0

As CBCS(L) increases by 1,000 head, CHRS(L) will tend to increase by 180 head and as the increase in CBCS(L) over last year is higher by 1,000 head over the increase of CBCS(L-1) over the previous year, the producers will tend to keep 101 head for beef cow replacements. The increase in CFSP4(L-1) by $1 per cwt would tend to make it profitable to farmers to sell feeder calves and cows, and to keep around 16 thousand head of young beef cows for replacements.

$$\begin{array}{llllll} 11. & \text{CHDS(L)} = 0.3035 & \text{CDCS(L)} & + 0.1613 & \$\ \text{CDCS(L)} \\ & (42.91) & & (1.784) & \\ & + 19.8481 & \text{CUP4(L-1)} & & \\ & (3.291) & & & \end{array}$$

$R^2 = 0.996$ S.E. = 98.250 D.W. = 1.4718 $\hat{\rho} = 0.7627$

F = 1580.3

The main economic effect will be the change in CUP4(L-1). If CUP4(L-1) increases by $1 per cwt the farmers will tend to sell their old cows and hence keep 20,000 head of young milk cows for replacements.

12. $\text{CHOS(L)} = \text{CHTS(L)} - \text{CHRS(L)} - \text{CHDS(L)}$

The number of the other cows and heifers that were not kept for milk or beef cows replacements CHOS(L) on farms January 1 is obtained through this equation.

<u>Fed beef production and consumption</u>

13. $$\text{PL1(L)} = -5392.6691 + \underset{(13.074)}{0.2981}\ \text{CBCS(L-1)} + \underset{(0.086)^{*}}{1.6949}\ \text{CSP4(L-1)/CP4(L-1)}$$

$R^2 = 0.9985$ S.E. = 218.7 D.W. = 2.1388 F = 1815.8

14. $$\text{PL2(L)} = -6407.8338 + \underset{(5.079)}{0.2598}\ \text{CBCS(L-1)} + \underset{(2.289)}{99.9747}\ \text{CSP1(L)/CP1(L)}$$

$R^2 = .9954$ S.E. = 364.043 D.W. = 1.286 F = 583.04

15. $$\text{PL3(L)} = -2040.9441 + \underset{(1.242)^{*}}{0.1654}\ \text{CCVS(L)} + \underset{(1.593)}{115.422}\ \text{CSP2(L)/CP2(L)}$$

$R^2 = 0.9916$ S.E. = 571.99 D.W. = 1.2264 F = 315.14

16. $$\text{PL4(L)} = -732.5885 + \underset{(2.477)}{0.1576}\ \text{CCVS(L)} + \underset{(4.581)}{176.847}\ \text{CSP3(L)/CP3(L)}$$

$R^2 = 0.9985$ S.E. = 358.53 D.W. = 1.5251 F = 1720.3

The logic used in the specification of the placements equations is discussed in Chapter II. The inclusion of some of the statistically insignificant variables was due to the correct sign effect obtained from those variables. Other previous specification was not consistent when estimated statistically with the a priori knowledge.

17. $APL(I) = PL(I-1) + PL(I-2) + PL(I-3)$

18. $$fcm(I) = 220.2288 + \underset{(14.327)}{0.30538}\ APL(I) - \underset{(0.083)}{0.0027}\ APL2(I)$$

$$- \underset{(0.027)}{0.0008}\ APL3(I) + \underset{(0.418)}{0.013}\ APL4(I) - \underset{(0.517)}{28.544}\ D2$$

$$+ \underset{(0.309)}{162.0309}\ D3 + \underset{(1.242)}{617.4028}\ D4$$

$R^2 = 0.9988$  S.E. = 211.4  D.W. = 1.5712  F = 3774.4

Almost 20 percent of the accumulated placements will be marketed in any given quarter. The APL4(I) will have the highest effect on the fed cattle marketed in the fall quarter. The level of the fcm(I) is highest in the fall quarter and lowest in the spring quarter.

19. $$FCM(I) = 245.44 + \underset{(50.797)}{1.0006}\ fcm(I)$$

$R^2 = .99$  S.E. = 78.93  F = 2580.4

20. $$FCADW(I) = 602.2359 + \underset{(3.669)}{0.9348}\ T(I)$$

$R^2 = 0.9991$  S.E. = 10.25  D.W. = 2.227  $\hat{\rho} = 0.4856$

F = 20370.0

21. $$FBQ(I) = -3348.05 + \underset{(33.369)}{5.3472}\ FCADW(I) + 0.6278$$

$$FCM(I) - \underset{(0.780)}{2.9052}\ D2 - \underset{(0.9655)}{4.1851}\ D3 + \underset{(1.6758)}{6.2809}\ D4$$

$R^2 = 0.9999$  S.E. = 10.923  D.W. = 1.9368  $\hat{\rho} = 0.5133$

F = 201510.0

The 1,000 head increase in FCM(I) will tend to increase FBQ(I) by 628,000 pounds. This indicates that the average dressing weight for a fed slaughtered animal is around 628 pounds which is a very reasonable approximation for published data (2, p. 15). On the other, a 1 pound increase in FADW(I) would equal the effect of slaughtering 8,515 head averaging 628 pounds (dressing weight) each. The significant change in the level of FBQ(I) is due mainly to the seasonality involved in FCM(I). The FBQ(I) level is highest in the fall quarter which followed the highest level of FCM(I), from equation 19.

Fed beef consumption identity

22. $\mathrm{FBCN(I)} = [\mathrm{FBQ(I)} - .5\ \mathrm{MBC(I)} - \mathrm{BEXP(I)}]/\mathrm{P(I)}$

Nonfed beef production

23.
$$\begin{array}{llllll}
\mathrm{CULS(I)} = -270.0317 & +\ 0.089 & \mathrm{CBCS1(I)} & +\ 0.101 & \mathrm{CBCS2(I)} & \\
 & (3.194) & & (3.315) & & \\
 & +\ 0.0686 & \mathrm{CBCS3(I)} & +\ 0.055 & \mathrm{CBCS4(I)} & \\
 & (2.199) & & (1.714 & & \\
 & -392.4662 & \mathrm{MFPR(I)} & -18.95 & \mathrm{CFSP(I-1)} & \\
 & (1.093) & & (2.45) & & \\
 & -463.2321\ \mathrm{D2} & +\ 970.75\ \mathrm{D3} & +\ 1624.5573\ \mathrm{D4} & & \\
 & (1.096) & (1.925) & (3.359) & &
\end{array}$$

$R^2 = 0.9683$ S.E. = 117.01 D.W. = 1.4313 $\hat{\rho} = 0.70996$

F = 103.79

This specification allows the comparison of the cull rates among quarters. The cull rate is highest in the 2nd calendar quarter - spring quarter - followed by the winter, summer, and fall quarters respectively. The $1 per cwt increase in CFSP(I-1) will tend to decrease the cull number in the current quarter by about 19,000 head. This reduction is a product of the producers' willingness to keep more cows to produce calves rather than for selling them for slaughter.

24. ONFCM(I) = 2480.8813 -0.1282 APL(I) -0.0323 APL2(I)
(5.905) (3.261)
-0.0252 APL3(I) + 0.0137 APL4(I) + 0.0993
(2.309) (1.375) (0.459)*
CHOS(I) -120.6857 CP(I-1) + 747.9052 D2
(1.262)* (4.234)
+ 580.9774 D3 - 387.3149 D4
(3.083) (2.35)

$R^2$ = 0.919 S.E. = 92.873 D.W. = 1.8436 $\hat{\rho}$ = 0.7514
F = 38.482

In general the more accumulated placements on feed for the specific quarter, the less ONFCM(I) are in that quarter. The effect of APL(I) is highest in the 3rd quarter and lowest in the fourth quarter. The level of ONFCM(I) is highest in the second quarter followed by the third, first, and fourth quarter respectively. The inclusion of CHOS(I) and CP(I-1) was based on a logical ground and was kept even given that the associated coefficients are statistically insignificant.

25. CAVS(I) = 479.1972 + 0.1192 CDCS(I) -18.553 VP(I)
(4.73) (5.358)
-191.4755 D2 -89.7625 D3 -20.5208 D4
(9.165) (3.697) (0.922)

$R^2$ = 0.9816 S.E. = 67.934 D.W. = 1.595 $\hat{\rho}$ = 0.6864
F = 338.90

As CDCS(I) increases by 1,000 head CAVS(I) tends to increase by 119 head. The $1 per cwt increase in VP(I) will make it profitable for the producers to slaughter vealer calves before they arrive to the 300-500 lb weight range and thus less calves will be available for slaughter at that weight. The equation indicates that the level of commercial calve slaughter is highest in the winter quarter followed by the fall, summer, and spring quarters respectively.

26. TNFCM = CULS(I) + ONFCM(I) + CAVS(I)

27. 
$$NFADW(I) = 327.215 \underset{(9.162)}{+ 38.7305} \; ONFCCR(I) \underset{(2.227)}{+ 2.069} \; D2 \underset{(0.254)}{- 9.666} \; D3 \underset{(2.677)}{- 8.738} \; D4$$

$R^2 = 0.999$ S.E. = 9.952 D.W. = 2.035 $\hat{\rho} = 0.3304$

F = 6799.9

The ratio between the number of nonfed cattle marketed to the number of commercial calves slaughtered is used as the major explanatory variable along with seasonal dummies to explain NFADW(I). The 1 point increase in the ratio, that is, if the total nonfed cattle marketings consisted of 50 percent cows, bulls and stags, steers, and heifers and 50 percent calves and then the percentage became 66 percent to 33 percent respectively, is considered to be a drastic change and hence NFADW(I) would increase by 39 pounds. The average dressing weight seems to be highest for animals slaughtered in the spring quarter and lowest for those slaughtered in the summer quarter.

$$
\begin{aligned}
28.\quad \mathrm{NFBQ(I)} = &- 1857.1896 + \underset{(24.439)}{4.4887}\ \mathrm{NFADW(I)} + 0.4121 \\
&\mathrm{TNFCM(I)} - \underset{(1.754)}{8.8214}\ \mathrm{D2} - \underset{(2.325)}{13.2912}\ \mathrm{D3} - 14.0049\ \mathrm{D4}
\end{aligned}
$$

$R^2 = 0.9993 \quad S.E. = 14.337 \quad D.W. = 1.4732 \quad \hat{\rho} = 0.7021$

$F = 9707.9$

The 1,000 head increase in the TNFCM in any quarter will tend to increase NFBQ in that quarter by 412,000 pounds, that is, the calculated NFADW is around 412 lb which is a close approximation for the data used in this study. The 1 lb increase in NFADW(I) will tend to increase NFBQ(I) by 4.49 million pounds, that is, the calculated average of TNFCM should be 10,895 head which is again an approximation for the average of the data used in this study. The level of NFBQ is highest in the winter quarter, followed by the spring, summer, and fall quarters respectively. This seasonality in NFBQ is due to the different seasonality affecting the previous estimated variables.

World trade - U.S. imports of nonfed beef - structure

The estimated structural coefficients were obtained through the use of 3SLS method. The structure of the system was estimated as follows:

$$
\begin{aligned}
29.\quad \mathrm{NEXSA(L)} = &-3370.0 + \underset{(.755)}{0.4006}\ \mathrm{NEXOC(L)} + \underset{(1.442)}{0.3558}\ \mathrm{NIMWE(L)} \\
&- \underset{(.462)}{0.3272}\ \mathrm{IMPUS(L)} - \underset{(.057)}{0.0327}\ \mathrm{NIMPRW(L)} + \underset{(0.221)}{0.4286} \\
&\mathrm{BQSA(L)} - \underset{(1.326)}{60.55}\ \mathrm{T(L)}
\end{aligned}
$$

30. $$\mathrm{NEXOC(L)} = -\ 787.4 - \underset{(.545)}{0.1578}\ \mathrm{NEXSA} - \underset{(.326)}{0.0647}\ \mathrm{NIMPWE(L)} + \underset{(.956)}{0.3401}\ \mathrm{IMPUS(L)} + \underset{(1.582)}{0.6101}\ \mathrm{NIMPRW(L)} + \underset{(3.628)}{0.6340}\ \mathrm{BQOC(L)} + \underset{(1.536)}{0.2721}\ \mathrm{CEOC(L)} - \underset{(1.336)}{31.6500}\ \mathrm{T(L)}$$

31. $$\mathrm{NIMPWE(L)} = 429.0 + \underset{(1.944)}{0.5532}\ \mathrm{NEXSA(L)} + \underset{(1.416)}{0.4431}\ \mathrm{NEXOC(L)} + \underset{(.368)}{0.1578}\ \mathrm{IMPUS(L)} + \underset{(1.154)}{0.4691}\ \mathrm{NIMPRW(L)} - \underset{(4.731)}{0.3835}\ \mathrm{BQWE(L)} + \underset{(.096)}{0.0541}\ \mathrm{CEWE(L)} + \underset{(1.625)}{71.47}\ \mathrm{T(L)}$$

32. $$\mathrm{IMPUS(L)} = -\ 4338.0 + \underset{(3.564)}{1.363}\ \mathrm{NEXSA(L)} + \underset{(3.001)}{1.293}\ \mathrm{NEXOC(L)} - \underset{(3.633)}{1.401}\ \mathrm{NIMPWE(L)} + \underset{(.302)}{0.2243}\ \mathrm{NIMPRW(L)} - \underset{(.822)}{34.5200}\ \mathrm{NFBPW(L-1)} + \underset{(2.523)}{0.1885}\ \mathrm{BQ(L-1)} + \underset{(1.207)}{1.526}\ \mathrm{DYN(L)} - 388.7\ \mathrm{T(L)}$$

33. $$\mathrm{NEXSA(L)} + \mathrm{NEXOC(L)} - \mathrm{NIMPWE(L)} - \mathrm{IMPUS(L)} - \mathrm{NIMPRW(L)} = 0$$

The derived reduced form of this system is presented in Appendix A. The reduced form equations are used in prediction - simulation model - and to obtain elasticities for U.S. imports with respect to foreign regions production. The IMPUS(L) equation, in the reduced form, is the equation of concern for this study. The reduced form for IMPUS(L) equation is solved for considering all the restrictions imposed on the structural equations of the specified system. Interpretation of these results and estimated elasticities of U.S. yearly imports with respect to foreign regions production are discussed in the next section.

The yearly level of imports for the U.S., IMPUS(L), is transformed to a quarterly basis according to the following equation.

34. $\mathrm{IMPUS}(I) = g \cdot (\mathrm{IMPUS}(L))$

$$\begin{aligned} \text{where } g &= 0.221 && \text{for } I = 1 \\ &= 0.225 && \text{for } I = 2 \\ &= 0.300 && \text{for } I = 3 \\ &= 0.254 && \text{for } I = 4 \end{aligned}$$

Those quarterly import levels were then used in obtaining the nonfed beef per capita civilian consumption, NFBCN(I), through the following identity.

<u>Nonfed beef consumption identity</u>

35. $\mathrm{NFBCN}(I) = [\mathrm{NFBQ}(I) - .5\ \mathrm{MBC}(I) + \mathrm{IMPUS}(I)]/P(I)$

<u>Wholesale price determination system structure</u>

36.
$$\begin{aligned} \mathrm{FBPW}(I) = {} & -8.535 + \underset{(0.748)}{0.425}\ \mathrm{NFBPW}(I) + \underset{(0.120)}{0.017}\ \mathrm{PPW}(I) \\ & + \underset{(1.589)}{0.373}\ \mathrm{BRPW}(I) - \underset{(1.738)}{0.288}\ \mathrm{TRPW}(I) - \underset{(1.613)}{2.038} \\ & \mathrm{FBCN}(I) + \underset{(0.078)}{0.0007}\ \mathrm{DYND}(I-1) - \underset{(0.33)}{0.344}\ \mathrm{UNEMP}(I) \\ & + \underset{(.09)}{0.601}\ \mathrm{CPI}(I) - \underset{(0.72)}{0.576}\ D2 - \underset{(0.44)}{0.6824}\ D3 \\ & - 0.938\ (0.279)\ D4 \end{aligned}$$

37. NFBPW(I) = 8.38 + 0.722 FBPW(I) + 0.135 PPW(I) - 0.327
(1.888) (1.272) (0.779)
BRPW(I) + 0.119 TRPW(I) - 0.683 NFBCN(I)
(0.663) (0.999)
- 0.00632 DYND (I-1) - 1.392 UNEMP(I) + 0.172
(0.632) (1.431) (0.886)
CPI(I) + 0.457 D2 - 0.279 D3 - 2.635 D4
(0.475) (0.202) (1.652)

38. PPW(I) = 57.44 + 0.0141 FPBW(I) + 0.803 NFBPW(I) + 0.1155
(0.022) (1.131) (0.308)
BRPW(I) - 0.008 TRPW(I) - 4.455 PCN(I)
(0.053) (7.359)
+ 0.0043 DYND(I-1) - 0.7316 UNEMP(I) + 0.1964
(0.53) (0.739)
CPI(I) - 4.577 D2 - 1.139 D3 + 5.372 D4
(5.867) (0.834) (2.166)

39. BRPW(I) = 25.86 + 0.1197 FBPW(I) + 0.4729 NFBPW(I)
(0.289) (0.749)
- 0.005 PPW(I) + 0.1766 TRPW(I) - 5.133
(0.052) (2.188) (3.748)
BRCN(I) + 0.0007 DYND (I-1) - 0.9137 UNEMP(I)
(0.096 (1.13)
+ 0.1324 CPI(I) + 4.09 D2 + 5.716 D3 - 1.112
(0.774) (3.485) (2.901) (0.601)
D4

$$
\begin{aligned}
40.\quad \mathrm{TRPW(I)} = {} & 20.82 + \underset{(0.269)}{0.3774}\ \mathrm{FBPW(I)} + \underset{(0.671)}{1.064}\ \mathrm{NFBPW(I)} \\
& + \underset{(0.89)}{0.2454}\ \mathrm{PPW(I)} - \underset{(0.213)}{0.182}\ \mathrm{BRPW(I)} - \underset{(3.11)}{22.22} \\
& \mathrm{TRCN(I)} + \underset{(0.948)}{0.021}\ \mathrm{DYND(I-1)} + \underset{(1.072)}{2.754}\ \mathrm{UNEMP(I)} \\
& - \underset{(1.353)}{0.7366}\ \mathrm{CPI(I)} + \underset{(1.851)}{4.338}\ \mathrm{D2} + \underset{(3.103)}{25.32}\ \mathrm{D3} \\
& + 78.32\ \mathrm{D4}
\end{aligned}
$$

From the structural equations the effect of the change in the fed beef wholesale price on the nonfed beef wholesale price is greater than the effect of the latter on the former. The $1/cwt increase in NFBPW(I) will tend to increase the FBPW(I) by 42 cents/cwt, while the $1/cwt increase in the FBPW(I) will tend to increase NFBPW(I) by almost 72¢/cwt. The nonfed beef wholesale price NFBPW(I) is more sensitive to changes in pork wholesale price than the fed beef wholesale prices. The $1/cwt increase in the PPW(I) will tend to increase NFBPW(I) and FBPW(I) by 13 ¢/cwt and 2 ¢/cwt respectively. The increase of $1 in DYND(I-1) will tend to increase FBPW(I) by one-seventh of a cent/cwt. The direction of the effect of DYND(I-1) on NFBPW(I) indicates that the nonfed beef is an inferior good which agrees with the previous studies. That is, the higher the real income is, the people will tend to consume less low quality beef (nonfed beef) and more of the other higher quality beef and meat. The broiler and turkey wholesale price variables BRPW(I) and TRPW(I) in the nonfed beef and fed beef wholesale price equations were associated with a priori unexpected sign of the coefficients, thus the comparison of the sensitivity of FBPW(I) and NFPW(I) for a change in those prices was not traced. The effect of the unemployment rate on FBPW(I) and NFBPW(I) is not similar. NFBPW(I) is affected by a 1 percent change in UNEMP(I) more than FBPW(I) is. The change in UNEMP(I) would affect in large the income of the workers that are originally the main consumers for the low quality beef. Those workers on the edge of unemployment are also margin consumers for fed beef, high quality beef. The 1 percent increase in unemployment rate will tend to decrease FBPW(I) and NFBPW(I) by 39¢/cwt and \$1.39/cwt respectively. That is, for a given supply of fed and nonfed beef and as unemployment increases by 1 percent the people will tend to decrease their consumption of nonfed beef more than they do for fed beef and that would bring about the previous effect. The effect of CPI(I) on meat prices is assumed to be nonlinear. Thus, the effect of CPI(I) on FBPW(I) and NFBPW(I) should be analyzed through the effect of DDYN(I-1) and CPI(I). From the structure estimation it could be concluded that the price flexibility of FBPW(I) is higher than its counterpart for NFBPW(I). If FBCN(I) increased by 1 pound then FBPW(I) tends to decrease by \$2.04/cwt, while if NFBCN(I) increased by 1 pound, NFBPW(I) will tend to decrease by only 68¢/cwt. That is, the FBPW(I) is more sensitive to changes in its own consumption than is the NFBPW(I). The effect of one specific exogenous variable (predetermined) variable on an endogenous variable is obtained from the reduced form equations presented in Appendix B.

### Farm prices - margin - equations

41. $$CSP(I) = 0.7422 + \underset{(16.235)}{0.6221}\ FBPW(I) - \underset{(1.533)}{1.8965}\ FMW(I)$$

$$\underset{(5.856)}{+\ 1.2849}\ \mathrm{CBYP(I)}\ \underset{(1.793)}{+\ 0.0715}\ \mathrm{T(I)}\ \underset{(0.388)}{+\ 0.0958}$$

$$\mathrm{D2}\ \underset{(1.044)}{+\ 0.2686}\ \mathrm{D3}\ \underset{(1.388)}{-\ 0.3614}\ \mathrm{D4}$$

$R^2 = 0.9997$ S.E. = 0.5734 D.W. = 1.9698 F = 14826.0

The $1/cwt increase in FBPW(I) will tend to increase CSP(I) by $.622/cwt. The increase of $1 in the cost of providing the existing service of food distribution and marketing will tend to decrease farm demand and farm supply with a consequence of decreasing CSP(I) by $1.9/cwt. If CBYP(I) increased by $1 the CSP(I) will tend to increase by $1.3.

42. $$\mathrm{CUP(I)} = -\ 1.0898\ \underset{(16.756)}{+\ 0.5116}\ \mathrm{NFBPW(I)}\ \underset{(.271)}{-\ 0.228}\ \mathrm{FWM(I)}$$

$$\underset{(3.66)}{+\ 0.7161}\ \mathrm{CBYP(I)}\ \underset{(0.851)}{+\ 0.0268}\ \mathrm{T(I)}\ \underset{(3.443)}{+\ 0.3727}\ \mathrm{D2}$$

$$\underset{(2.249)}{+\ 0.2973}\ \mathrm{D3}\ \underset{(0.736)}{+\ 0.1076}\ \mathrm{D4}$$

$R^2 = 0.9996$ S.E. = 0.2927 D.W. = 1.833 $\hat{\rho} = 0.3787$

F = 10831.0

The $1/cwt increase in NFBPW(I) will tend to increase CUP(I) by $.51/cwt while the $1 increase in CBYP(I) will tend to increase CUP(I) by $.72/cwt. The $1 increase in FMW(I) will tend to lower CUP(I) by $.23/cwt.

43. $$\mathrm{CFSP(I)} = -\ 0.3681\ \underset{(8.015)}{+\ 0.9865}\ \mathrm{CSP(I)}\ \underset{(2.331)}{+\ 0.3081}\ \mathrm{CFBI(I-1)}$$

$$\underset{(3.167)}{+\ 0.2556}\ \mathrm{T(I)}\ \underset{(1.585)}{+\ 0.763}\ \mathrm{D2}\ \underset{(0.872)}{-\ 0.5091}\ \mathrm{D3}$$

$$- 0.493 \quad D4$$
$$(0.823)$$

$R^2 = 0.9799$ S.E. = 1.5949 D.W. = 0.881 $\hat{\rho} = 0.7414$

$F = 257.61$

CFSP(I) is highly related to CSP(I) and as CSP(I) increases by $1/cwt, CFSP(I) will tend to increase by $.99/cwt. The increase in cattle feeding profitability will tend to raise demand of feeder steers and CFSP(I) will increase by $.31/cwt.

## Interpretation and Analysis of Results

From the estimated model a few points have been observed regarding the significance of separating the cattle-beef sector in the U.S. to the fed and nonfed subsectors. Also, results were obtained regarding the significance of the effect of foreign region's production of beef and veal upon the U.S. consumers and producers. Those results supported the assumptions used in constructing the model.

The following general results were observed:

1. The larger number of cattle placed on feed takes place at the fourth quarter of the year, fall quarter. The largest coefficient in the placement equations is associated with heifers, steers, and bulls less than 500 pounds on farms at the beginning of the year. The seasonal pattern involved in marketing the fed cattle follows the pattern involved in placing cattle on feed.

2. The average dressing weight for the fed cattle is stable over quarters of the year and does not include any seasonal pattern. The

seasonality involved in the fed beef commercial production results mainly from the seasonal pattern involved in the marketing of fed cattle.

3. The level of the average dressing weight of nonfed cattle differs significantly among the seasons of the year. It is highest for animals slaughtered during the second quarter, spring quarter. This pattern follows from the fact that the level of steers and heifers marketed as nonfed cattle, the heaviest weight category of TNFCM(I), is highest in that quarter. The commercial nonfed beef production is highest in the first quarter, winter quarter, where the cull number is in its peak level. This indicates that during the sample period (1963-1973) the increase in the number of nonfed cattle marketed, especially cull beef and dairy cows, was a significant variable to bring more increase in NFBQ(I) than does the trend to fatten the cattle on grass.

4. The elasticities, using data means, of the U.S. imports with respect to the foreign region's yearly production of beef and veal were calculated as follows:

$E_{IMP/BQSA} = 1.5699$

$E_{IMP/BQOC} = 1.088$

$E_{IMP/BQWE} = 4.1927$

Those elasticities were calculated from the previously reported reduced form. The 1 percent change in the production level of beef and veal in South America will have a greater impact on the U.S. imports than does a 1 percent change in the production of Oceania. The percentage change in the beef and veal production in Western Europe will bring the greatest impact on the U.S. level of imports. This observation is explained mainly by the diversification of South American exports from

Western Europe to create pressure on the U.S. imports. The high elasticity could also be due to the recent situation of Western Europe as being on the margin of self sufficiency in beef production and consumption. Thus a percentage increase in Western Europe's production could actually bring direct imports to the U.S. from that region where no veterinary restrictions are imposed on its shipment of beef.

5. From the derived reduced form of the wholesale price determination equation system it was observed that the effect of a 1 pound change in the level of the per capita consumption of fed beef has a greater impact on the change in the price level of both FBPW(I) and NFBPW(I) than does the change in the level of NFBCN(I). It is also concluded that the wholesale price of fed beef, FBPW(I), is more flexible to change in fed beef per capita consumption, FBCN(I), than is the wholesale price of nonfed beef, NFBPW(I), to changes in per capita consumption of nonfed beef, NFBCN(I), Table III-1.

The direct and cross price flexibilities for fed and nonfed beef are lower than those obtained by Houck (17) but the distribution and interrelations are about the same. The cross price flexibilities for pork, broiler and turkey are drastically different with respect to a percentage change in fed and nonfed beef consumption. The price flexibilities for broiler and turkey with respect to the percentage change in fed beef consumption is unusually high and inconsistent. However, these results proved the existence of a significantly different effect for the two homogeneous types of beef on their own prices and prices of other meats. This fact was hidden through using beef as a homogeneous product.

Table III-1. Flexibility matrix obtained from the reduced form, Appendix B, using data means

| Wholesale prices of | The effect of 1 percent change in the per capita consumption of FB | NFB | P | BR | TR |
|---|---|---|---|---|---|
| FB | -0.994 | -0.069 | -0.035 | -0.351 | 0.240 |
| NFB | -0.918 | -0.249 | -0.330 | 0.675 | 0.145 |
| P | -0.602 | -0.158 | -1.568 | -0.064 | 0.087 |
| BR | -1.125 | -0.244 | -0.399 | -1.579 | -0.072 |
| TR | -1.457 | -0.309 | -0.824 | 0.096 | -0.868 |

6. The effect of the percentage change in foreign region's production of beef and veal upon the U.S. domestic wholesale prices of the included meat items were obtained through the use of the previously estimated elasticities and the effect of such change on the level of NFBCN(I), Table III-2. The 10 percent increase in the production of South America has greater impact on the U.S. domestic wholesale prices than does the same percentage change in Oceania's production. The highest effect of changes in the production level of Western Europe is explained through the previously discussed reasons. The effect of a 10 percent increase in the beef and beef production in South America, Oceania, and Western Europe is equivalent, according to the estimates of this model, to the effect of a 2.96, 2.04 and 7.89 percent change in the U.S. quarterly domestic civilian per capita consumption of nonfed beef. The significant effect of the production of beef and veal in the foreign regions on the U.S. imports and

Table III-2. The effect of the production of beef and veal in the foreign regions upon the U.S. domestic wholesale prices of fed beef, nonfed beef, pork, broiler, and turkey

| Quarterly wholesale prices of | The effect of 10 percent change in the yearly production of beef and veal in (percentage change) | | |
|---|---|---|---|
| | South America | Oceania | Western Europe |
| FB | -0.204 | -0.139 | -0.540 |
| NFB | -0.738 | -0.511 | -1.969 |
| P | -0.467 | -0.322 | -1.245 |
| BR | -0.721 | -0.499 | -1.926 |
| TR | -0.9122 | -0.633 | -2.385 |

prices of the fed and nonfed beef and the other meat items justify the significance of solving for the U.S. imports level through a simultaneous equation system that includes those foreign regions.

7. Since the U.S. imports are estimated to be elastic with respect to percentage change in production of foreign regions, the effect of a 10 percent change in U.S. yearly imports, using data means, on the quarterly wholesale prices of the included meat items ought to be smaller than the direct effect of a 10 percent change in the production of the foreign regions. The 10 percent change in U.S. imports will tend to change FBPW(I), NFBPW(I), PPW(I), and TRPW(I) by 0.13, 0.47, 0.30, 0.46, and 0.582 percent respectively. The different response of FBPW(I) and NFBPW(I) to this percentage changes in the level of imports again justifies the constructed structure of cattle-beef sector as divided to fed and nonfed components.

8. The effect of a 10 percent change in the beef and veal production in the foreign regions and in U.S. level of imports on farm prices of choice steers, cow utility, and choice feeder steers is estimated in Table III-3. The following estimates were calculated using 27.84 dollars, 17.69 dollars, and 33.70 dollars as the mean value of CSP(I), CUP(I), and CFSP(I) respectively.

The highest effect of such 10 percent change in foreign region's production level and in the level of the U.S. imports of nonfed beef is always on the cow utility prices, CUP(I), i.e., the nonfed cattle.

Those general interpretations and analyses of the results obtained from the estimated structure support the considerations made in developing the recursive quarterly econometric model for the fed and nonfed cattle-beef sector, namely, beef is not a homogeneous product, and the existence of a significant effect of disturbances occurs in the rest of the world on the livestock-meat economy of the U.S.

Table III-3. The effect of percentage changes in beef and veal production in foreign regions and U.S. imports on farm prices

| Farm prices of | The effect of 10 percent change in the beef and veal production in (percentage change) | | | The effect of 10 percent change in U.S. yearly imports |
|---|---|---|---|---|
| | South America | Oceania | Western Europe | |
| CS | -0.212 | -0.145 | -0.563 | -0.135 |
| CU | -0.793 | -0.548 | -2.114 | -0.504 |
| CFS | -0.173 | -0.118 | -0.459 | -0.120 |

# CHAPTER IV. SIMU VI - A MODIFIED QUARTERLY SIMULATION MODEL FOR THE LIVESTOCK-MEAT ECONOMY

## Introduction

In this chapter[1] the estimated model for the fed and nonfed cattle-beef sector presented in the previous chapter is integrated with a more comprehensive quarterly simulation model for the livestock and poultry economy of the U.S. - SIMU V (27).[2] This integration constitutes the formation of SIMU VI, the modified quarterly simulation model for the livestock-meat economy. The formation of SIMU VI through this integration is to provide intermediate term quantitative economic multiple prediction for use by economic agencies in the livestock-meat economy, and to assist testing an important hypothesis regarding the validity and accuracy of the two models. The tested hypothesis states that the accuracy of the simulation results from SIMU VI is not an improvement over the accuracy of the simulation of SIMU V where beef is treated as a homogeneous product and

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[1] The materials presented in this chapter depend heavily on that of Rahn (30) and Mann (27).

[2] In his unpublished Ph.D. thesis, Rahn (30) has reported the third version of the simulation model, SIMU III. Mann et al. (27) after making few modifications has developed the fourth verion, SIMU IV. In those versions of the model, the quarterly classification of month was on seasonal rather than calendar quarter basis. Prior to the analysis on hand, SIMU IV was re-estimated completely using calendar quarterly data and SIMU V was developed by Robert Remele, a current graduate research assistant, Department of Economics, Iowa State University. SIMU V has the exact functional relations - structure, used the same statistical techniques to estimate the unknown parameters, and used the same accuracy analysis and computer program as those of SIMU IV. While the comparison made in this chapter is between SIMU V (after minor modifications to build common basis for comparison) and SIMU VI, the references to SIMU V are made through (27) where SIMU IV is the actual reported model.

the U.S. livestock-meat economy was explicitly assumed to be isolated from disturbances occurring in other parts of the world. Through respecifying the structural relations involved in constructing the cattle-beef sector in such a way as presented in the previous chapter, the simulation is expected to be affected and hence tested against those of SIMU V according to specific accuracy indices.

One of the major advantages of simulation is that it permits study of the real system without actual modification of that system in any way. For real economic systems, major experimentations involve very high risk and may lead to catastrophe. The validity of a simulation is affected by the appropriate structure of the model used as being within the postulates of economic and mathematical theories (29), and by its ability to represent the crucial essence of the relationships existing in the real system. The cattle-beef sector's structure as presented in SIMU V doesn't represent the crucial essence of the true structure as being divided to fed and nonfed. Also, crucial essence of the true structure was ignored through ignoring the simultaniety involved between the U.S. and the other major regions of the world beef economy in determining the level of U.S. nonfed beef imports. Thus the need for developing a simulation model in this study also stems from the need to examine the validity and accuracy criteria used for SIMU V. After the preliminary analysis was done to determine the need for developing a simulation analysis, and after the formulation of the problem as stated in Chapter I and constructing and estimating the model, Chapters II and III respectively, the computer program was developed for SIMU VI and that of SIMU V was modified to fit the comparison on hand. The validity criteria used for SIMU V are retained and applied to SIMU VI. These similar accuracy indices were then used as tools to test the previously stated hypothesis.

A review of SIMU V along with the formation of SIMU VI is presented in the second part of this chapter. The third is devoted to the discussion of the validation and comparison method. The exogenous variables forecasts needed for simulation, the simulation results, and the evaluation of SIMU VI are presented in the last two parts.

## Review of SIMU V and the Formation of SIMU VI

The SIMU V model (27) was constructed and estimated not only to provide intermediate term forecasts of the endogenous variables, but also to aid in understanding the interrelationships which exist among variables in the system. The model encompassed five livestock and poultry commodities. These are beef cattle, swine, sheep, broiler, and turkey. The quarterly classification of months reformed in this version on calendar rather than seasonal basis.

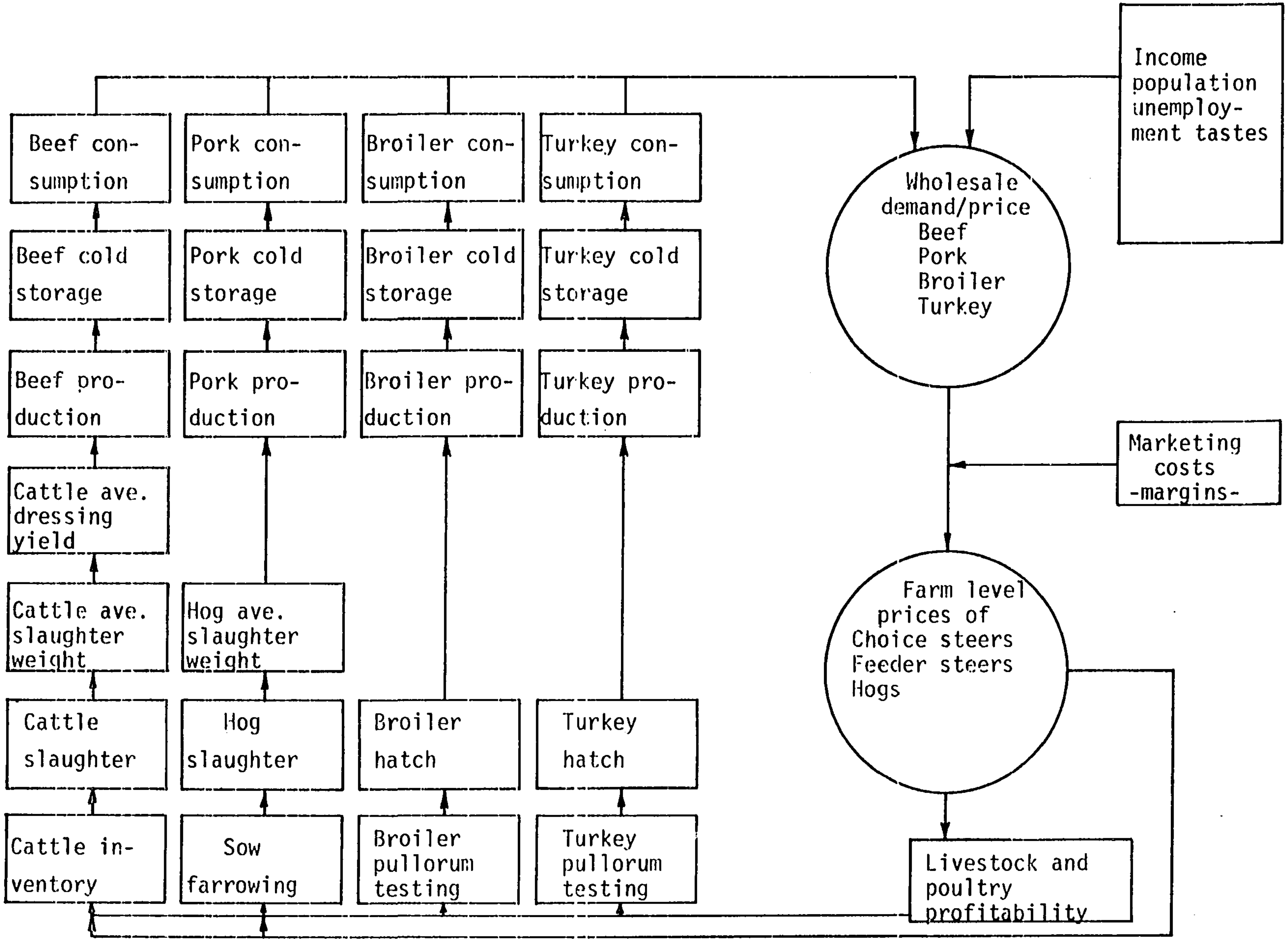
The model contained 48 endogenous variables, equations, and 24 exogenous variables. The model is complete in the sense that each endogenous variable has a structural equation specified for its determination. The equations in the model were ordered in a recursive manner with one small block of five simultaneous equations. Within each sector for any given quarter, the causal chain begins with relationships that depict inventory or other fundamental production variables. The ordering then, in general, proceeds through slaughter equations, average slaughter weight equations, live to carcass or ready-to-cook production weight equations, cold storage equations, foreign trade equations, and supply-disappearance identity equations. To determine the wholesale price levels of the five commodities, a simultaneous system of derived demand equations is utilized at this juncture. The corresponding farm price levels are derived through the farm to wholesale margin equations. Then, these price variables provided the primary production set decision variables assumed to be used by livestock and poultry producers in establishing their desired future production level. However, to keep the model as comparable as possible with the proposed SIMU VI, the sheep sector was deleted from the model. The omission of the sheep sector was mainly due to the belief, through results of primary investigation for this study, that the prices of lambs have insignificant effect upon the prices of other meats and that the consumption of lamb has little effect on changes in other meat prices and the prices of lamb itself. This omission resulted from the need to re-estimate the now four equation derived wholesale demand system and the revision of the overall weights used for the verification process. A visual representation of SIMU V as used in this study to test the stated hypothesis is given in Figure IV-1, where rectangles represent variables and circles are used to represent price.

In constructing the sixth version of the simulation model, the SIMU V model as stated above was modified as follows:

1. The fed and nonfed cattle-beef sector as presented and estimated in this study was substituted for the original cattle-beef sector.

2. The wholesale price system for the five commodities, namely, fed beef, nonfed beef, pork, broiler, and turkey estimated in the previous chapter has replaced the four equation derived wholesale demand system for the beef, pork, broiler, and turkey prices.

Figure IV-1. Visual representation of SIMU V as used in this study


Income population unemployment tastes
Wholesale demand/price Beef Pork Broiler Turkey
Marketing costs -margins-
Farm level prices of Choice steers Feeder steers Hogs
Livestock and poultry profitability
Beef consumption
Pork consumption
Broiler consumption
Turkey consumption
Beef cold storage
Pork cold storage
Broiler cold storage
Turkey cold storage
Beef production
Pork production
Broiler production
Turkey production
Cattle ave. dressing yield
Cattle ave. slaughter weight
Hog ave. slaughter weight
Cattle slaughter
Hog slaughter
Broiler hatch
Turkey hatch
Cattle inventory
Sow farrowing
Broiler pullorum testing
Turkey pullorum testing

3. The per capita civilian consumption variables for pork, broiler, and turkey, i.e., PCN, BRCN, and TRCN respectively, were treated as exogenous variables in the wholesale price system estimated in Chapter II. However, in SIMU VI those variables are treated as endogenous in the system and predetermined in the wholesale price system of SIMU VI.

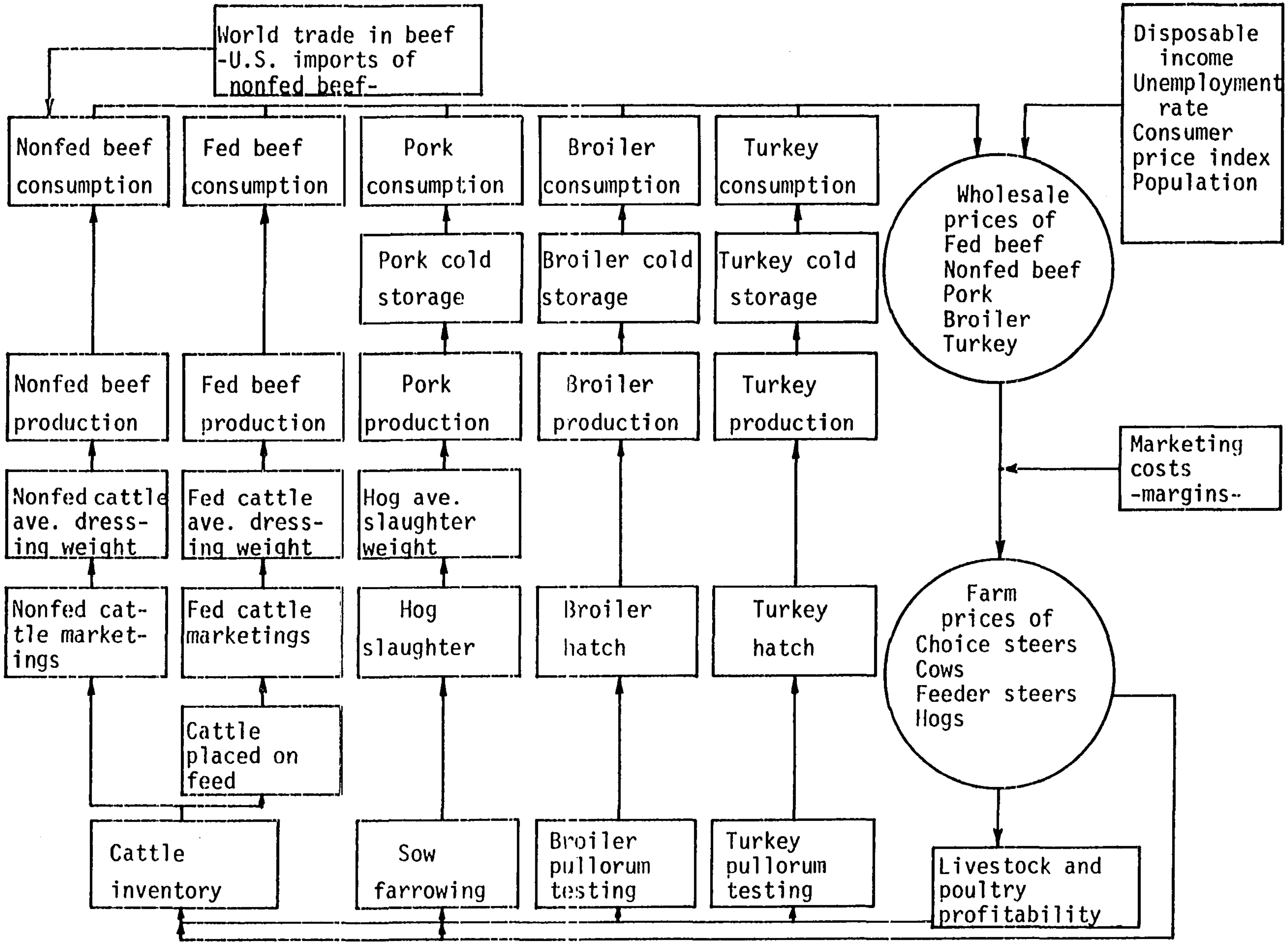
Other than those modifications, all specifications used in the swine, broiler, and turkey sectors were retained. Through those modifications the structure of SIMU VI was completed with a total of 64 endogenous variables, equations, and 33 exogenous variables. The causal chain for any quarter within each sector is the same as discussed earlier in this section.

In order to avoid numerous repetitions, the specification of the structural relations of the complete modified model for the livestock-meat economy in the U.S. - SIMU VI - is not presented in this study. The equations specified and estimated for the pork, broiler, and turkey sectors along with the relevant used endogenous and exogenous variables are presented clearly in (27). However, a visual representation of SIMU VI is provided in Figure IV-2.

## Validation and the Comparison Method

The primary purpose behind performing the previous changes on SIMU V and constructing SIMU VI is to compare the simulation results from the two models. To achieve that purpose, certain accuracy indices are developed and used. The accuracy analysis to measure the degree of imperfection for the forecast is but one step in the validity of a simulation model. Validity of a simulation is a measure of the extent to which it satisfies

Figure IV-2. Visual representation of SIMU VI as used in this study



World trade in beef -U.S. imports of nonfed beef-
Disposable income
Unemployment rate
Consumer price index
Population
Nonfed beef consumption
Fed beef consumption
Pork consumption
Broiler consumption
Turkey consumption
Wholesale prices of
Fed beef
Nonfed beef
Pork
Broiler
Turkey
Pork cold storage
Broiler cold storage
Turkey cold storage
Nonfed beef production
Fed beef production
Pork production
Broiler production
Turkey production
Marketing costs -margins-
Nonfed cattle ave. dressing weight
Fed cattle ave. dressing weight
Hog ave. slaughter weight
Nonfed cattle marketings
Fed cattle marketings
Hog slaughter
Broiler hatch
Turkey hatch
Farm prices of
Choice steers
Cows
Feeder steers
Hogs
Cattle placed on feed
Cattle inventory
Sow farrowing
Broiler pullorum testing
Turkey pullorum testing
Livestock and poultry profitability

its design objective. It refers to the capability of being able to justify and defend a simulation model. The concept of validity does not require nor imply that the simulation is valid if it precisely matches the real system. This goal is an impractical one. In general, validity can be improved by using models that are parametric insofar as possible (26). Parameters in a simulation are variables that denote the state of the environment and the underlying characteristics of a system. Its use instead rather than constants wherever possible makes it easier to modify the system characteristics and thus increase the validity of the simulation during development. However, there are certain criteria agreed upon by fellow professionals for a simulation model to be valid (24). One of those agreed upon criteria is related to the appropriate construction of the model within the postulates of economic and mathematical theories. The model should also capture and represent in large the essence of relationships existing in the real system. Another criterion for the validity of a simulation model is that the unknown parameters are generated through a sound quantitative system and statistical theory. The third criterion deals with the accuracy index of the simulation model as being within some arbitrarily determined acceptable maximum. Whereas verification amounts to testing the hypothesis that the forecasting procedure is correct, accuracy analysis deals with the degree to which the forecasts are imperfect (36, p. 23). In this study validity is used for verification where the whole simulation procedure is examined, while the accuracy analysys is considered as a subset of the verification or validity process of a simulation model.

SIMU VI is more parametric than SIMU V through representing the comprehensive structural relations in the beef cattle sector to capture the essence of the real system as being divided to fed and nonfed components. According to the first criterion for model validation, the use of different causal chains to explain the phases of production and marketing in the fed and nonfed beef subsectors emerged from economic, observed physical, and logical phenomena. The inclusion of the accounting equation and the adjustment process in the yearly inventory equations will aid in representing the real system's balancing behavior of the number of cattle and calves on farms from one year to another. Thus the first criterion for validation is satisfied in SIMU VI. Given the statistical theory and methods considered and used in estimating the fed and nonfed cattle-beef sector, the second stated criterion for model validation is satisfied in both SIMU V and SIMU VI.

Cyert (9) suggested that many measures could be appropriately used for the accuracy analysis. Those measures include the turning point concepts and its subconcepts, average amplitude over the whole series, average matching of variables and the exact matching of values of variables. Since the purpose of using accuracy analysis for SIMU VI was also to compare its simulation accuracy with that of SIMU V, the accuracy indices used for SIMU V are retained and developed for SIMU VI. By doing that a common criterion for comparison is used. Those accuracy indices developed for both models are used as tools for testing the previously stated hypothesis.

Almost all the measures used for accuracy analysis are applied to one equation at a time. To approach the problem of deciding upon the superiority of a model's over all performance, a disutility function or statistical loss function whose value is to be minimized is constructed

(27, p. 67). The accuracy analysis performed on the two models was done through the construction of a loss function. If the statistic measure of goodness of fit of any equation is denoted by $C_j$, thus the loss function is defined as

$$C = f(C_1, \ldots., \ldots., C_j: h_1, \ldots, \ldots, h_k)$$

where $C_j$ is either an absolute percentage error or inequality coefficient for the jth equation in the model; and $h_j$ is a specified parameter to determine the value of the loss function for each set of values of the $C_j$. The loss function as used in this study was defined to be linear

$$C = \sum_j C_j h_j$$

Thus C is measured through the percentage error index and the Theil inequality coefficient. It provides a single overall measure of performance of a model or a sector of a model. The smallest number of C identifies the superior model. To explain the two accuracy indices, the following definitions are used.

A(i,j) = the observed values of the jth endogenous variable for the ith time period (i=1, ..., N; J=1, ..., M)

$A(i,j) = the observed change in the value of the jth endogenous variable over the ith time period (i=2, ..., N; J=1, ..., M)

P(i,j) = the predicted value of the jth endogenous variable for the ith time period (i=1, ..., N; J=1, ..., M)

$P(i,j) = the predicted change in the value of the jth endogenous variable over the ith time period (i=2, ..., N; J=1, ..., M)

M = the number of endogenous variables of concern for accuracy

N = the number of time periods endogenous variable estimates are to be generated over

Using the simple percentage error index as the first measure of $C_j$, the first accuracy measure for evaluating the exact matching of the estimated and observed ordered is

$$EI(i,j) = 100.0 * P(i,j)/A(i,j) \qquad i,j$$

The use of this measure to provide an index of the average matching of the jth endogenous variable vector of estimated and observed values over the N time periods is defined as

$$EI(\cdot,j) = 100.0 * \sum_{i=1}^{N} [P(i,j)-A(i,j)]/ \sum_{i=1}^{N} A(i,j) \qquad j$$

Given that $h_i$ is a proportional weight ( $\sum_{j=1}^{M} h(j) = 1$), thus an aggregate accuracy index is defined as

$$EI(\cdot,\cdot) = \sum_{j=1}^{M} h(j)\ EI(\cdot,J)$$

The second used accuracy index is Theil's inequality coefficient (36, p. 21). The measure of the jth endogenous variable is defined as the square root of

$$U^2(j) = \sum_{i=2}^{N} [\$P(i,j) - \$A(i,j)]^2/ \sum_{i=1}^{N} \$A(i,j)^2$$

and the overall aggregate accuracy index is given by

$$U(\cdot) = \sum_{j=1}^{M} h(j)\ U(j)$$

Those two indices are then developed for SIMU VI and are used to test the accuracy of simulation resulting only from altering the structure of the cattle-beef sector in such manner as discussed in Chapters II and III.

To identify the superior model, the following criterion is used, using percentage error index notations for illustration. If EI(·,·) SIMU V > EI(·,·) SIMU VI; EI(beef) SIMU V > EI(beef) SIMU VI, then model SIMU VI is proved to be superior over model V and the hypothesis stating that the accuracy of simulation results from SIMU VI is not an improvement over that of SIMU V is rejected and vice versa.

The effect of separating beef into fed and nonfed on the accuracy of simulation results for other sectors in the model, which affects the overall accuracy indices, is considered in comparing the overall simulation accuracy for the two models. This effect is expected due to the different cross effects for fed and nonfed on the other meat sectors as indicated in Table III-1.

For applying the above stated indices and criteria, the proportional ranking which indicates the importance of the estimation of accuracy of the respective variable in outlook endeavors are needed. The proportional weights are derived from these proportional rankings. For the comparison between the two overall indices to be meaningful, the proportional weights used for variables within the cattle-beef sector should be the same in the two models. The number of endogenous variables in the fed and nonfed cattle-beef sector's structure is larger than that of the cattle-beef sector in SIMU V. To overcome this problem, the endogenous variables used in the cattle-beef sector in SIMU V were categorized according to the different phases and nature, e.g., wholesale price variables, farm price variables, stock variables, production variables, and slaughter and dressing weight variables. The weight associated to each category was calculated from SIMU V. The relevant variables in SIMU VI under each group were assigned proportional importance indexes such that the weight of the category is kept the same. The proportional weights used for the cattle-beef sector in SIMU VI are presented in Table IV-1. The weights used for each sector within the model to construct the overall accuracy indices are the proportional contribution of each sector to the total farm cash receipt. The same weights were used for the cattle-beef, pork, broiler, and turkey in the two models, Table IV-2.

## Exogenous Variables Forecasts

Since both SIMU V and SIMU VI are open simulation models, the forecasts of the time paths of the exogenous variables are prerequisites to endogenous variables' forecasts. The type of prediction results from those simulation models is conditional prediction (36, p. 6). The forecasted values of the endogenous variables are obtained given the forecasted values of the basic exogenous variables. The value of endogenous variables' forecasts is then conditioned by the accuracy of the exogenous variables forecasts.

Eleven variables of the 33 exogenous variables used in SIMU VI are not used in SIMU V. Those are FARM(L), DLOSD(L), PMC(L), MCN(L), BQSA(L), BQOC(L), BQWU(L), CEOC(L), CEWU(L), MFPR(I), VP(I), and BEXP(I). The time paths of the other 22 exogenous variables, that are used in both SIMU V and SIMU VI models, are estimated previously through the development of SIMU V (27, p. 94). These forecasts are retained and used by SIMU VI in order to obtain reliable comparison results. A systematic method was used in obtaining an initial forecast values for those 11 exogenous variables. Those values were then adjusted according to the author's expectations,

Table IV-1. SIMU VI beef sector aggregate accuracy index weights

| Rank order | Variable name | Priority index | Proportional weight |
|---|---|---|---|
| 1 | FBPW | 1334 | 0.0996 |
| 2 | CSP | 1250 | 0.0903 |
| 3 | CBCS | 1240 | 0.0895 |
| 4 | CSTS | 1200 | 0.0866 |
| 5 | CCVC | 985 | 0.0711 |
| 6 | FBQ | 700 | 0.0505 |
| 7 | CHTS | 680 | 0.0492 |
| 8 | NFBPW | 666 | 0.0481 |
| 9 | PL | 650 | 0.0469 |
| 10 | CCVC | 640 | 0.0463 |
| 11 | CUP | 600 | 0.0433 |
| 12 | CDCS | 580 | 0.0419 |
| 13 | fcm | 550 | 0.0397 |
| 14 | CHRS | 490 | 0.0354 |
| 15 | CHDS | 470 | 0.0339 |
| 16 | BULS | 465 | 0.0336 |
| 17 | TNFCM | 450 | 0.0324 |
| 18 | CFSP | 350 | 0.0254 |
| 19 | NFBQ | 300 | 0.0217 |
| 20 | FADW | 120 | 0.0086 |
| 21 | IMPUS | 75 | 0.0054 |
| 22 | NFADW | 55 | 0.0040 |

Table IV-2. SIMU V and SIMU VI models aggregate accuracy index weights

| Subsector | Cash receipts[a] (1967-1971 average) | Proportional weight |
|---|---|---|
| Beef | 12,803,447 | 0.6752 |
| Pork | 4,285,753 | 0.2260 |
| Broiler | 1,409,075 | 0.0743 |
| Turkey | 465,195 | 0.0245 |
| All subsectors | 18,963,470 | 1.0000 |

[a] Cash receipts from farm marketings and value of products consumed in farm households.

Tables IV-3 and IV-4. A simple linear trend, extrapolation, regression equation was used for that purpose, where the number of observations used are those of the initial econometric models. The simple trend equation used was of the form

$$Y(i) = B_0 + B_1T(i) + E(i)$$

where i = (I) for variables used quarterly

i = (L) for variables used yearly

The coefficients obtained from this equation for each variables were then used to obtain its time path.

For a simulation result to be meaningful, the model's users should be informed about the values and assumptions used in obtaining the forecasts of the key exogenous variables in the model. Assumptions and relations used to forecast variables such as CP(I), SBMP(I), DYN(I), P(I), UNEMP(I),

Table IV-3. Yearly exogenous variables forecasts 1976-1979

| Year | Million pounds | | | Dollars | | Pounds | | 1,000 head | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BQSA | BQOC | BQWE | CEOC | CEWE | PMC | MCN | FARM | DLOSD | NIMPL |
| 1976 | 13517.6 | 3646.8 | 15933.6 | 2255.6 | 1872.7 | 11095.8 | 518.8 | 403.6 | 6782.0 | 620.0 |
| 1977 | 13739.6 | 3738.7 | 16190.2 | 2341.6 | 1952.5 | 11345.9 | 510.1 | 386.7 | 8100.0 | 800.0 |
| 1978 | 13961.6 | 3829.1 | 16446.9 | 2427.5 | 2032.4 | 11595.9 | 501.6 | 369.8 | 8050.0 | 700.0 |
| 1979 | 14183.6 | 3919.5 | 16703.5 | 2513.4 | 2112.2 | 11846.0 | 493.0 | 352.8 | 7900.0 | 1000.0 |

Table IV-4. Quarterly exogenous variables forecasts, fourth quarter 1975 until fourth quarter 1979

| Year and quarter | | MFPR | VP | BEXP |
|---|---|---|---|---|
| 1975 | 4 | 1.82 | 63.93 | 36.84 |
| 1976 | 1 | 1.82 | 64.77 | 37.23 |
| | 2 | 1.83 | 65.61 | 37.63 |
| | 3 | 1.84 | 66.44 | 38.02 |
| | 4 | 1.85 | 67.28 | 38.42 |
| 1977 | 1 | 1.86 | 67.28 | 38.81 |
| | 2 | 1.87 | 68.12 | 39.21 |
| | 3 | 1.88 | 68.96 | 39.60 |
| | 4 | 1.88 | 69.79 | 39.99 |
| 1978 | 1 | 1.89 | 70.63 | 40.39 |
| | 2 | 1.90 | 71.47 | 40.79 |
| | 3 | 1.91 | 72.30 | 41.18 |
| | 4 | 1.92 | 73.14 | 41.58 |
| 1979 | 1 | 1.92 | 73.98 | 41.97 |
| | 2 | 1.93 | 74.63 | 42.37 |
| | 3 | 1.94 | 76.49 | 42.76 |
| | 4 | 1.95 | 77.33 | 43.16 |

FMW(I) and FLW(I) are of concern to economic agencies involved in the livestock-meat and feed economy.

In SIMU V and SIMU VI models, CP(I) is assumed to decrease until it reaches the believed equilibrium price of $2.20 per bushel by the fourth quarter of 1976. SBMP(I) equilibrium price was projected at $130.00 per ton by the first quarter of 1978. The expected world wide relative shortage in protein is used as a base for such prediction. DYN(I) is assumed to increase by the rate of 6 percent by 1976 and 5 percent thereafter. UNEMP(I) is assumed to decrease slowly until it reaches 7.2 percent by 1976, 6.4 percent by 1977 and 5.5 percent thereafter. P(I) is assumed to increase by 1 percent annually in the forecasting period. FMW(I) and FLW(I) are assumed to increase by 3.5 percent and 7 percent per year respectively.

## Simulation Results and Evaluation of SIMU VI

In order to obtain comparable simulated time paths for endogenous variables in the SIMU VI and SIMU V models, the same exogenous variables' forecasts were used, for exogenous variables commonly used in the two models, in both models. The exogenous variables' forecasts were then used in the computer programs to simulate the time paths of the endogenous variables for the period of the first quarter of 1965 until the fourth quarter of 1979. The mode of operation[1] used in both programs replaces estimates by actuals after one quarter, mode = 1. The coefficients used to relate the quarterly variables in the SIMU VI model are estimated using a sample period from the first quarter of 1963 until the fourth quarter of 1973, while those used to relate the quarterly variables in the SIMU V model are estimated using a sample period from the first quarter of 1963 until the fourth quarter of 1972. The effect of the difference in the sample period upon the comparison of the accuracy of simulation is

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[1] The mode of operation defines when actual values of the endogenous variables of the model are used to replace estimates when any endogenous variable is used as an independent variable to estimate endogenous variables in the model (27, p. 77).

expected to be minimal since the two sample periods are 91 percent congruent. The same test period is used in both models, i.e., from the first quarter of 1965 until the fourth quarter of 1973. Thus, the first test period is actually part of the sample period and the model, SIMU VI, should simulate best during the period used to estimate its coefficients. Accordingly, the accuracy indices, e.g., average percentage error indices and Theil's inequality coefficients, are calculated between estimates and actual observations starting in the first quarter of 1965 until the fourth quarter of 1973.

The SIMU VI model produces simulated time paths for 64 endogenous variables, while SIMU V model produces simulated time paths for 42 endogenous variables. The calculated average percentage error indices and Theil's inequality coefficients for selected endogenous variables common for both models are presented in Table IV-5. Both the average percentage error indices and Theil's inequality coefficients indicated that CBCS, CCVS, CCVC, AND CSTS are predicted with higher degree of accuracy in SIMU V, while CFSP was simulated with higher degree of accuracy in the SIMU VI model. Apparently the consideration given to the different cross effects of the fed and nonfed components in the demand system in SIMU VI has surprisingly improved the accuracy of simulation for the wholesale price variables for nonbeef meat items. The accuracy of prediction for PPW, BRPW, and TRPW of SIMU VI is superior over that of SIMU V as measured by both the average percentage error indices and Theil's inequality coefficients. Of course all variables in the pork, broiler, and turkey sectors which are estimated in the sequential order before the wholesale

Table IV-5. The average percentage error index and Theil's inequality coefficient for selected endogenous variables common for both SIMU VI and SIMU V models, calculated from the first quarter of 1965 until the fourth quarter of 1973

| Variable name[1] | Average percentage error index | | Theil's inequality coefficient | |
|---|---|---|---|---|
| | SIMU VI | SIMU V | SIMU VI | SIMU V |
| CBCS | 0.929 | 0.853 | 0.390 | 0.335 |
| CCVS | 2.012 | 1.614 | 0.901 | 0.768 |
| CCVC | 1.470 | 0.776 | 1.453 | 0.470 |
| CSTS | 1.341 | 2.488 | 0.653 | 1.175 |
| CFSP | 3.999 | 6.406 | 0.719 | 1.097 |
| PQ | 2.353 | 2.353 | 0.363 | 0.363 |
| PPW | 3.874 | 7.158 | 0.682 | 0.907 |
| HP | 4.373 | 7.392 | 0.441 | 0.622 |
| BRQ | 1.515 | 1.515 | 0.265 | 0.265 |
| BRPW | 5.112 | 7.732 | 0.707 | 1.010 |
| TRQ | 5.682 | 5.682 | 0.078 | 0.078 |
| TRPW | 8.771 | 10.316 | 1.220 | 1.955 |

[1] PQ = pork commercial production (mil. lb); HP = hog prices ($/cwt); BRQ = broiler production (mil. lb); TRQ = turkey production (mil. lb).

price determination stage have exactly the same simulated time paths and hence the same accuracy indices in SIMU VI and SIMU V.

Individual accuracy indices for variables within the beef sector are combined using the proportional weights specified in Table IV-1 to obtain the beef sector accuracy indices for SIMU VI. Individual accuracy indices for variables within the beef sector of SIMU V and the nonbeef sectors of SIMU V and SIMU VI are combined using the same proportional weights specified by Rahn (30, pp. 155-156). The individual accuracy indices for sectors within the model are then combined using the proportional weights specified in Table IV-2 to obtain the overall model indices, Table IV-6. The overall or model indices are used as tools to test the hypothesis that the accuracy of simulation results from SIMU VI model is not an improvement over that from SIMU V model. According to Theil's inequality coefficients, SIMU VI provided more accurate simulation for all sectors and hence for the overall model. This result implied the rejection of the hypothesis of no improvement. SIMU VI model is accepted to be a more accurate simulation than SIMU V. According to the Theil's inequality criteria, partitioning beef into fed and nonfed improved not only the accuracy of simulation for the beef sector but also for all other meat sectors. Improvement of the simulation of nonbeef sectors by partitioning beef is apparently due to the unique important position of beef in the meat economy. To have two kinds of beef to enter the wholesale price determination system allows the model to isolate the significantly different direct and cross effect of fed and nonfed beef on each of the other meat sectors. With only one type of beef SIMU V had to estimate a single average relationship and apply this to the heterogeneous beef supply of changing composition.

Using the other criteria, i.e., the average percentage error, the simulation of SIMU VI is slightly less accurate for the cattle-beef sector than that of SIMU V. Again, the price simulation results for nonbeef sectors are more accurate, and as a result the overall SIMU VI model has a

Table IV-6. The overall percentage error index and Theil's inequality coefficient for SIMU VI and SIMU V models and for the sectors within each, calculated from the first quarter of 1965 until the fourth quarter of 1973

| | Average percentage error index | | Theil's inequality coefficient | |
|---|---|---|---|---|
| | SIMU VI | SIMU V | SIMU VI | SIMU V |
| Beef sector | 2.6189 | 2.5145 | 0.6639 | 0.7257 |
| Pork sector | 3.3923 | 4.9069 | 0.4263 | 0.5242 |
| Broiler sector | 3.8572 | 4.8187 | 0.4818 | 0.5932 |
| Turkey sector | 8.0366 | 8.4848 | 0.4769 | 0.7033 |
| Model | 3.0184 | 3.3727 | 0.5921 | 0.6698 |

lower average percentage error inspite of a slightly larger beef sector's average percentage error. Thus the comparison seems inconclusive. The inclusion of fed and nonfed worsened the accuracy in the cattle-beef sector but helped through the significantly different cross effects to improve the accuracy of estimating the wholesale prices for pork, broiler, and turkey. That is dividing beef helped the model to obtain more accurate prediction for other meat sectors in the system but not for beef.

To test the model's ability to simulate outside the sample period, the actual values for the first, second, and third quarters of 1974 for all endogenous and exogenous variables in both models were included. Unfortunately the accuracy of simulation for 1974 was relatively poor. The accuracy indices were recalculated for the period of the first quarter of 1965 to the third quarter of 1974. The estimated, observed, and percentage error index (EI) for selected endogenous variables of SIMU VI cattle-beef sector for the first quarter of 1967 through the fourth quarter of 1977 are presented in Appendix C. The average percentage error indices and Theil's inequality coefficients for selected endogenous variables common for both models are presented in Table IV-7.

Table IV-7. The average percentage error index and Theil's inequality coefficient for selected endogenous variables common for both SIMU VI and SIMU V models, calculated from the first quarter of 1965 until the third quarter of 1974

| Variable name | Average percentage error index |  | Theil's inequality coefficient |  |
|---|---|---|---|---|
|  | SIMU VI | SIMU V | SIMU VI | SIMU V |
| CBCS | 1.102 | 0.975 | 0.434 | 0.360 |
| CCVS | 1.786 | 2.195 | 0.678 | 1.046 |
| CCVC | 2.343 | 0.999 | 2.330 | 0.714 |
| CSTS | 1.303 | 2.467 | 0.481 | 0.879 |
| CFSP | 8.607 | 7.824 | 1.794 | 1.063 |
| PQ | 2.6807 | 2.681 | 0.408 | 0.408 |
| PPW | 7.192 | 8.782 | 1.306 | 1.057 |
| HP | 7.666 | 8.984 | 0.988 | 0.785 |
| BRQ | 2.001 | 2.001 | 0.421 | 0.421 |
| BRW | 9.769 | 7.515 | 1.455 | 0.794 |
| TRQ | 5.657 | 5.657 | 0.080 | 0.080 |
| TRPW | 10.775 | 13.509 | 1.3211 | 1.929 |

The inclusion of the first three quarters of 1974 increased the error indices for many of the endogenous variables in the models. The overall result was a worsening of SIMU VI relative to SIMU V. The accuracy indices for the variables of SIMU VI were increased more by adding 1974 than were those of SIMU V. The error indices for wholesale price variables have doubled. The ten years error index for farm prices in the cattle-beef sector of SIMU VI almost doubled by adding 1974. Of course error indices for individual variables were combined with same proportional weights when recalculating the overall accuracy indices for SIMU VI and SIMU V models, Table IV-8. Both the average percentage error index and Theil's inequality coefficients for the SIMU V model and its cattle-beef sector, including 1974, are smaller than those for the SIMU VI model. Accordingly, the hypothesis that separating beef into fed and nonfed would not improve the simulation failed to be rejected. In predicting the first three quarters of 1974, SIMU V model is more accurate than the SIMU VI model. However, the average percentage error indices showed that the accuracy of simulation for pork and turkey sectors of SIMU VI have improved through the use of the new structural relations specified in the cattle-beef sector. Theil's inequality coefficients indicated that only the turkey sector's simulation was improved. Although there is some inconsistency between the two criteria on specific sector, the overall capacity of SIMU VI to forecast 1974 is definitely inferior to SIMU V.

It is true that both SIMU VI and SIMU V failed to forecast the situation of the first three quarters of 1974. SIMU VI did relatively less well, but 1974 was an unusual year. During that period drastic changes occurred within the cattle-beef sector. The composition of beef

Table IV-8. The overall percentage error index and Theil's inequality coefficient for SIMU VI and SIMU V models and for the sectors within each, calculated from the first quarter of 1965 until the third quarter of 1974

| | Average percentage error index | | Theil's inequality coefficient | |
|---|---|---|---|---|
| | SIMU VI | SIMU V | SIMU VI | SIMU V |
| Beef sector | 3.9823 | 2.9681 | 1.009 | 0.7445 |
| Pork sector | 5.0772 | 5.7777 | 0.7210 | 0.6127 |
| Broiler sector | 5.8160 | 4.9891 | 0.8176 | 0.5749 |
| Turkey sector | 9.3216 | 10.1807 | 0.5284 | 0.7171 |
| Model | 4.4968 | 3.9300 | 0.9181 | 0.7015 |

between fed and nonfed shifted dramatically. Inspite of SIMU VI being able to reflect this shift in composition, the result was worse in the calculated accuracy indices for SIMU VI more than for SIMU V. From examining the data for the nonfed beef variables, it was observed that the number of culled beef and dairy cows, CULS(I), have increased by 26 percent in the third quarter of 1974 from a year earlier. The average annual percentage change from 1968 until 1973 for CULS(I) was only 6.6 percent. The nonfed steer and heifer marketings, ONFCM(I), reached an all time high of 1438 thousand head in the third quarter of 1974. This was a 96.9 percent increase over the level of the previous quarter and 1954.0 percent over the level of the third quarter of 1973. SIMU VI failed to predict these dramatic changes in nonfed beef production. Also, the level of civilian consumption of nonfed beef, NFBC(I), increased by 41 percent in the third quarter of 1973. During 1970-1972, NFBC(I) was increasing by a rate of only 12 percent per year. During the sample period the wholesale price of nonfed beef, NFBPW(I), increased rather regularly and considerably from the first quarter of 1963 until the third quarter of 1973. However it decreased by 17.3 and 9.1 percent in the second and third quarters of 1974 respectively. Furthermore, the level of utility cow price, CUP(I), decreased by 49.1 percent in the third quarter of 1974 from a year earlier.

Perhaps the unusual situation in 1974 was the reason for obtaining high error indices. Perhaps SIMU VI is less able to forecast outside the sample period than SIMU V. Thus, the real comparison between SIMU VI and SIMU V and the evaluation of SIMU VI model's ability to forecast is left uncertain. If the future supported the idea that the situation in 1974 and 1975 within the cattle-beef sector is transitory, that is, the situation in the years thereafter will coincide with the historical trend existed during the sample period, then SIMU VI will be of value in providing accurate forecasts for use by economic agencies involved in the livestock-meat economy. However, if the future situation indicates that the existing dramatic shift in the composition of beef between fed and nonfed of 1974 and 1975 is a real one that would persist for a long time, then SIMU VI will not be able to provide accurate forecasts.

The criteria used to evaluate the simulation accuracy of SIMU VI and to compare it with SIMU V under the two test periods is but one criteria in evaluating the validity of SIMU VI. The validity of SIMU VI as a positive simulation model is measured also by the extent to which it satisfies its designed objectives. SIMU VI has positively identified and quantified the comprehensive and crucial structural relationships for the cattle-beef sector in the United States. Despite the failure to provide accurate forecasts for 1974 and 1975 situation, the presented model incorporates potentials to improve its performance. Those potentials stem from the flexible and parametric nature of the econometric model used. SIMU VI can be used to analyze the separate effect of changes in a specific exogenous variable or a group of exogenous variables on the two components of beef. The effect of potential changes in the level of beef and veal production in a foreign region upon the U.S. livestock-meat economy could be analyzed through SIMU VI. Such analysis is of great interest to policy makers and other agencies involved in the livestock-meat economy in the United States.

# CHAPTER V. SUMMARY AND CONCLUSIONS

This study is conducted to identify and quantify the structural relations in the fed and nonfed cattle-beef sector in the U.S., to provide adequate intermediate term quantitative economic prediction, and to examine the impact of separating fed from nonfed beef in an econometric simulation for the livestock-meat economy. In this structure, the U.S. yearly imports of nonfed beef is treated as an endogenous variable. The determination of the level of imports of nonfed beef is affected by U.S. domestic factors and the level of net export - net import, production, and income level of the major regions in the world beef economy. Surprisingly, the U.S. meat economy is more affected by the changes in the production level of Western Europe than in Oceania.

Separating fed from nonfed in the cattle-beef sector of a simulation model for the livestock-meat economy improved the simulation accuracy of other meat sectors in the model, i.e., pork, broiler, and turkey sectors. The separation of fed from nonfed beef allowed the model to isolate significantly different direct and cross effects of those two components of beef on each of the other meat sectors. The accuracy of simulation was measured by the average percentage error indices and Theil's inequality coefficients. Apparently the two indices generally agreed in identifying the superior sector or model. However, the two calculated indices for the models and sectors within each are heavily dependent upon the proportional weights used to combine the individual variables with the sector or sectors within the model. Different weights would provide different accuracy indices and may conclude differently concerning the superiority of the simulation of a sector or model.

The situation in 1973, 1974, and 1975 was hard to simulate. In this period, the cattle-beef sector experienced a dramatic shift in its composition of fed and nonfed. It is not yet certain if the situation in those 3 years - 12 calendar quarters - represents a real shift that would persist in the future, or if it represents a temporary dramatic shift from the situation existing in the past 11 years from 1962 until 1972 - 44 calendar quarters. On that basis it was impossible for this study to predict which model, i.e., SIMU V or SIMU VI, will forecast best in the future. If the situation of 1973, 1974, and 1975 represents a real shift, more observations are needed to fit the SIMU VI model's structural relations in order to estimate more accurate and precise coefficients - or dummy variables could be used to distinguish between the two different time periods.

To achieve the first objective of the study, namely, to identify and quantify the structural relations in the cattle-beef sector, a 43 equation positive quarterly econometric recursive model was developed and statistically estimated. The model involves two blocks of five equations each, for the wholesale price determination relations and for the U.S. yearly imports, world trade, determination relations, that are of simultaneous nature. The coefficients of the other stochastic equations in the system were estimated considering the presence of autocorrelation among the disturbance terms. In specifying the yearly inventory equations for cattle and calves on farms at the beginning of a year, an accounting procedure was incorporated to ensure the balance of the number of cattle and calves on farms from one year to another. To represent the existing interrelationships between the U.S. and the other major regions of the world beef economy, in determining the U.S. yearly import level of nonfed beef, the world was divided into five major regions, namely, South America, Oceania, Western Europe, the United States, and the rest of the world. The wholesale prices of fed and nonfed beef were solved for simultaneously with other meat prices, i.e., pork, broiler, and turkey. The results from this system successfully isolated significant direct and cross price flexibilities for those two types of beef. The second objective of the study was to provide adequate intermediate term quantitative economic prediction for use by agencies in the livestock-meat economy, and to examine the effect of separating fed from nonfed beef in an econometric simulation. To achieve this objective, the estimated model for the fed and nonfed cattle-beef sector was integrated with SIMU V - a previously developed and estimated quarterly simulation econometric model for the livestock-meat economy in the U.S. (27). This model, as used in the study, encompassed four livestock and poultry commodities, namely, beef cattle, swine, broiler, and turkey. This integration formulated SIMU VI, a modified quarterly simulation econometric model for the livestock-meat economy. SIMU VI contains 64 endogenous variables - equations, and 33 exogenous variables. Computer programs were then used to simulate time paths for the endogenous variables of both models from the first quarter of 1965 until the fourth quarter of 1979.

The simulation accuracy indices, i.e., average percentage error indices and Theil's inequality coefficients developed and used by SIMU V, were retained and used by SIMU VI. The comparable accuracy indices were then used as tools to test the hypothesis - in its null form - that the accuracy of simulation results from SIMU VI, i.e., from separating fed from nonfed beef, is not an improvement over that of SIMU V. The two models used in the comparison have used the same exogenous variables forecasts - for commonly used exogenous variables - and the same mode of operation. The models differ slightly in the sample period used to estimate the coefficients in each.

Despite the failure of SIMU VI to provide accurate forecasts for 1974 and 1975, the presented structure of the cattle-beef sector as being separated to fed and nonfed is believed to be the true structure. The presented fed and nonfed cattle-beef sector has potential for improvements. These potentials stem from the flexible and parametric nature of the model used. The separation of fed from nonfed beef and the consideration given to incorporate the effect of disturbances generated in other parts of the world on the U.S. meat economy in an econometric simulation would provide researchers, policy makers, and other agencies with better understanding for the true and comprehensive structural relationships involved in the sector.

## Suggestion for Further Studies

In the world trade system, highly aggregated variables were used to develop and estimate the five simultaneous equations. The results of this highly aggregated and crude model are not expected to accurately capture the effect of disturbances generated in other regions of the world on the U.S. livestock-meat economy. Disaggregation of this model - data permitting - in terms of countries within the regions and in terms of causal order chain of production, consumption, and trade probably would aid in obtaining more accurate analysis for such effect. In addition, to capture the true interrelationship between the U.S. livestock-meat economy and the rest of the world, a simple econometric model investigating the production, consumption, and trade relations for grain in major regions of the world probably should be linked to the SIMU VI model.

More study should be given to locating the actual primary market level for meat. Are meat prices really empirically established at the retail or wholesale market level? A study oriented toward answering such a question will be a welcomed addition in the price analysis field.

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# APPENDIX A. THE DERIVED REDUCED FORM EQUATIONS FOR THE WORLD TRADE SIMULTANEOUS EQUATION SYSTEM

$$\begin{aligned}\mathrm{NEXSA}(L) = {} & 1017.5234 + 0.4309\ \mathrm{BQSA}(L) + 0.2831\ \mathrm{BQOC}(L) + 0.1215\ \mathrm{CEOC}(L) \\ & - 0.2333\ \mathrm{BQWE}(L) + 0.0329\ \mathrm{CEWE}(L) + 17.0874\ \mathrm{NFBPW}(L-1) \\ & - 0.0933\ \mathrm{BQ}(L-1) - 0.7554\ \mathrm{DYN}(L) + 160.8778\ \mathrm{T}(L)\end{aligned}$$

$$\begin{aligned}\mathrm{NEXOC}(L) = {} & - 1735.6316 - 0.0406\ \mathrm{BQSA}(L) + 0.6919\ \mathrm{BQOC}(L) + 0.2970 \\ & \mathrm{CEOC}(L) + 0.1522\ \mathrm{BQWE}(L) - 0.0215\ \mathrm{CEWE}(L) + 4.0377 \\ & \mathrm{NFBPW}(L-1) - 0.0220\ \mathrm{BQ}(L-1) - 0.1785\ \mathrm{DYN}(L) - 11.7114\ \mathrm{T}(L)\end{aligned}$$

$$\begin{aligned}\mathrm{NIMPWE}(L) = {} & 4838.7266 + 0.2322\ \mathrm{BQSA}(L) + 0.5109\ \mathrm{BQOC}(L) + 0.2193 \\ & \mathrm{CEOC}(L) - 0.4240\ \mathrm{BQWE}(L) + 0.0599\ \mathrm{CEWE}(L) + 20.3391 \\ & \mathrm{NFBPW}(L-1) - 0.1111\ \mathrm{BQ}(L-1) - 0.8991\ \mathrm{DYN}(L) + 249.7299\ \mathrm{T}(L)\end{aligned}$$

$$\begin{aligned}\mathrm{IMPUS}(L) = {} & - 10798.6094 + 0.2000\ \mathrm{BQSA}(L) + 0.5464\ \mathrm{BQOC}(L) + 0.2345 \\ & \mathrm{CEOC}(L) + 0.4491\ \mathrm{BQWE}(L) - 0.0634\ \mathrm{CEWE}(L) - 28.0387 \\ & \mathrm{NFBPW}(L-1) + 0.1531\ \mathrm{BQ}(L-1) + 1.2395\ \mathrm{DYN}(L) - 454.9482\ \mathrm{T}(L)\end{aligned}$$

$$\begin{aligned}\mathrm{NIMPRW}(L) = {} & 5241.7773 - 0.0420\ \mathrm{BQSA}(L) - 0.0822\ \mathrm{BQOC}(L) - 0.0353 \\ & \mathrm{CEOC}(L) - 0.1061\ \mathrm{BQWE}(L) + 0.0150\ \mathrm{CEWE}(L) + 28.8248 \\ & \mathrm{NFBPW}(L-1) - 0.1574\ \mathrm{BQ}(L-1) - 1.2742\ \mathrm{DYN}(L) + 354.3855\ \mathrm{T}(L)\end{aligned}$$

# APPENDIX B. THE DERIVED REDUCED FORM EQUATIONS FOR THE WHOLESALE PRICE DETERMINATION SIMULTANEOUS EQUATION SYSTEM

FBPW(I) = - 1.2503 - 2.6430 FBCN(I) - 0.3276 NFBCN(I) - 0.1034 PCN(I)
- 1.9228 BRCN(I) + 5.5725 TRCN(I) - 0.0069 DYND(I-1)
- 2.1641 UNEMP(I) + 1.1014 CPI(I) - 0.1898 D2 - 5.2539 D3
- 22.4137 D4

NFBPW(I) = 9.5021 - 1.9417 FBCN(I) - 0.9485 NFBCN(I) - 0.7751 PCN(I)
+ 0.2941 BRCN(I) + 2.6842 TRCN(I) - 0.0099 DYND(I-1)
- 2.6686 UNEMP(I) + 0.9272 CPI(I) - 1.4688 D2 - 4.6219 D3
- 13.0155 D4

PPW(I) = 69.0071 - 1.7778 FBCN(I) - 0.8373 NFBCN(I) - 5.1446 PCN(I)
- 0.3888 BRCN(I) + 2.2520 TRCN(I) - 0.0042 DYND(I-1) - 3.2000
UNEMP(I) + 1.0468 CPI(I) - 5.3576 D2 - 4.3858 D3 - 5.8668 D4

BRPW(I) = 37.0379 - 1.7863 FBCN(I) - 0.6975 NFBCN(I) - 0.7060 PCN(I)
- 5.1465 BRCN(I) - 0.9936 TRCN(I) - 0.0035 DYND(I-1) - 2.6324
UNEMP(I) + 0.8330 CPI(I) + 3.5312 D2 + 5.7997 D3 - 0.2742 D4

TRPW(I) = 40.6518 - 3.1746 FBCN(I) - 1.2113 NFBCN(I) - 1.9977 PCN(I)
+ 0.4285 BRCN(I) - 16.5275 TRCN(I) + 0.0073 DYND(I-1)
- 1.2083 UNEMP(I) + 0.7675 CPI(I) + 0.7461 D2 + 16.2876 D3
+ 54.6228 D4

## APPENDIX C. ESTIMATED, OBSERVED, AND PERCENTAGE ERROR INDEX VALUES FOR SELECTED ENDOGENOUS VARIABLES FOR THE SIMU VI CATTLE-BEEF SECTOR FOR THE FIRST QUARTER OF 1967 THROUGH FOURTH QUARTER OF 1977

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CBCS | | | CCVS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1967 | 1 | 33,974 | 33,770 | 100.6 | 27,439 | 28,138 | 97.5 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1968 | 1 | 34,281 | 34,570 | 99.2 | 27,524 | 28,461 | 96.6 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1969 | 1 | 35,291 | 35,490 | 99.4 | 28,437 | 28,780 | 98.8 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1970 | 1 | 36,480 | 36,689 | 99.4 | 29,013 | 29,609 | 98.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1971 | 1 | 38,014 | 37,877 | 100.4 | 29,922 | 30,235 | 99.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1972 | 1 | 39,201 | 38,807 | 101.0 | 30,892 | 31,688 | 97.5 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1973 | 1 | 40,312 | 40,918 | 98.5 | 32,833 | 32,229 | 101.9 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CBCS | | | CCVS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1974 | 1 | 43,910 | 42,874 | 102.4 | 33,948 | 33,954 | 100.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1975 | 1 | 45,010 | | | 33,952 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1976 | 1 | 48,207 | | | 35,972 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1977 | 1 | 53,465 | | | 39,157 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| | | | BULS | | | CSTS | |
| 1967 | 1 | 2,151 | 2,155 | 99.8 | 14,860 | 14,780 | 100.5 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1968 | 1 | 2,158 | 2,195 | 98.3 | 14,778 | 14,820 | 99.7 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1969 | 1 | 2,206 | 2,220 | 99.4 | 14,975 | 14,905 | 100.5 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1970 | 1 | 2,231 | 2,272 | 98.2 | 15,206 | 15,265 | 99.6 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | BULS | | | CSTS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1971 | 1 | 2,287 | 2,327 | 98.3 | 15,712 | 15,610 | 100.7 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1972 | 1 | 2,335 | 2,376 | 98.3 | 16,116 | 15,999 | 100.7 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1973 | 1 | 2,370 | 2,465 | 96.2 | 17,335 | 16,655 | 104.1 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1974 | 1 | 2,496 | 2,642 | 94.5 | 17,607 | 17,788 | 99.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1975 | 1 | 2,637 | | | 18,098 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1976 | 1 | 2,721 | | | 18,973 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1977 | 1 | 2,867 | | | 20,798 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| | | | CCVS | | | CCVC | |
| 1967 | 1 | 28,137 | 28,138 | 100.0 | 43,782 | 43,763 | 100.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CCVS | | | CCVC | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1968 | 1 | 28,450 | 28,461 | 100.0 | 43,795 | 44,239 | 99.0 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1969 | 1 | 28,749 | 28,780 | 99.9 | 44,467 | 45,196 | 98.4 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1970 | 1 | 29,583 | 29,609 | 99.9 | 45,783 | 45,871 | 99.8 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1971 | 1 | 30,209 | 30,235 | 99.9 | 47,034 | 46,739 | 100.6 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1972 | 1 | 31,661 | 31,688 | 99.9 | 48,440 | 47,695 | 101.6 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1973 | 1 | 32,397 | 32,339 | 100.2 | 52,157 | 49,034 | 106.4 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1974 | 1 | 33,974 | 33,954 | 100.1 | 54,750 | 50,000 | 109.5 |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1975 | 1 | 34,624 | | | 54,535 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |

| Year and quarter | | CCVS | | | CCVC | | |
|---|---|---|---|---|---|---|---|
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1976 | 1 | 37,155 | | | 57,779 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| 1977 | 1 | 40,106 | | | 62,827 | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| | | | PL | | | FCM | |
| 1967 | 1 | 4,623 | 4,587 | 100.8 | 5,245 | 5,371 | 97.7 |
| | 2 | 3,854 | 3,832 | 100.6 | 5,451 | 5,718 | 95.3 |
| | 3 | 4,672 | 5,046 | 92.6 | 5,453 | 5,463 | 99.8 |
| | 4 | 7,484 | 7,614 | 98.3 | 5,373 | 5,374 | 100.0 |
| 1968 | 1 | 4,711 | 5,066 | 93.0 | 5,505 | 5,813 | 94.7 |
| | 2 | 4,432 | 4,420 | 100.3 | 5,806 | 5,981 | 97.9 |
| | 3 | 5,266 | 5,941 | 88.6 | 5,839 | 6,032 | 96.8 |
| | 4 | 8,173 | 8,365 | 97.7 | 5,998 | 5,870 | 102.2 |
| 1969 | 1 | 4,946 | 5,093 | 97.1 | 6,188 | 6,195 | 99.9 |
| | 2 | 4,740 | 5,197 | 91.2 | 6,313 | 6,109 | 103.3 |
| | 3 | 5,624 | 5,767 | 97.5 | 6,313 | 6,313 | 100.0 |
| | 4 | 7,977 | 8,482 | 94.1 | 6,198 | 6,227 | 99.5 |
| 1970 | 1 | 5,215 | 5,119 | 101.9 | 6,408 | 6,412 | 99.9 |
| | 2 | 4,949 | 5,242 | 94.4 | 6,304 | 6,482 | 97.2 |
| | 3 | 5,528 | 6,146 | 90.0 | 6,370 | 6,619 | 96.2 |
| | 4 | 7,612 | 7,994 | 95.2 | 6,341 | 6,429 | 98.6 |
| 1971 | 1 | 5,566 | 5,734 | 97.1 | 6,388 | 6,477 | 98.6 |
| | 2 | 4,914 | 5,455 | 90.1 | 6,457 | 6,524 | 99.0 |
| | 3 | 5,412 | 6,371 | 85.0 | 6,674 | 6,840 | 94.6 |
| | 4 | 8,452 | 8,842 | 95.0 | 6,677 | 6,424 | 103.9 |
| 1972 | 1 | 5,938 | 5,933 | 100.1 | 6,781 | 6,689 | 101.4 |
| | 2 | 6,085 | 6,364 | 95.6 | 6,842 | 6,673 | 98.1 |
| | 3 | 6,495 | 6,224 | 104.4 | 7,069 | 7,153 | 98.8 |
| | 4 | 9,077 | 8,862 | 102.4 | 6,983 | 7,021 | 99.5 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | PL | | | FCM | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1973 | 1 | 6,208 | 6,040 | 102.8 | 7,020 | 6,831 | 102.8 |
| | 2 | 6,135 | 5,696 | 107.7 | 6,836 | 6,529 | 104.7 |
| | 3 | 5,916 | 5,283 | 112.0 | 6,905 | 6,204 | 111.3 |
| | 4 | 7,656 | 7,513 | 101.9 | 6,505 | 6,706 | 97.0 |
| 1974 | 1 | 6,857 | 5,292 | 129.6 | 6,116 | 6,245 | 97.9 |
| | 2 | 5,616 | 4,028 | 139.4 | 5,916 | 6,517 | 90.8 |
| | 3 | 5,225 | 4,624 | 113.0 | 5,757 | 5,768 | 99.8 |
| | 4 | 6,850 | | | 5,525 | | |
| 1975 | 1 | 7,419 | | | 5,202 | | |
| | 2 | 6,282 | | | 6,160 | | |
| | 3 | 5,648 | | | 6,891 | | |
| | 4 | 7,751 | | | 7,247 | | |
| 1976 | 1 | 8,321 | | | 6,479 | | |
| | 2 | 7,451 | | | 7,016 | | |
| | 3 | 6,526 | | | 7,796 | | |
| | 4 | 8,883 | | | 8,186 | | |
| 1977 | 1 | 9,488 | | | 7,451 | | |
| | 2 | 8,791 | | | 7,978 | | |
| | 3 | 7,309 | | | 8,906 | | |
| | 4 | 9,723 | | | 9,234 | | |
| | | | FCADW | | | FBQ | |
| 1967 | 1 | 617.89 | 626.50 | 98.6 | 3242.49 | 3365.10 | 96.4 |
| | 2 | 623.13 | 623.80 | 99.9 | 3398.71 | 3567.00 | 95.3 |
| | 3 | 622.30 | 610.30 | 102.0 | 3395.10 | 3334.1 | 101.8 |
| | 4 | 616.22 | 612.70 | 100.6 | 3322.79 | 3292.6 | 100.9 |
| 1968 | 1 | 617.87 | 618.30 | 99.9 | 3403.86 | 3594.0 | 94.7 |
| | 2 | 621.07 | 619.10 | 100.3 | 3608.33 | 3671.6 | 98.3 |
| | 3 | 621.94 | 609.50 | 102.0 | 3633.35 | 3676.4 | 98.8 |
| | 4 | 617.76 | 619.20 | 99.8 | 3717.89 | 3634.5 | 102.3 |
| 1969 | 1 | 622.95 | 613.30 | 101.6 | 3857.39 | 3799.7 | 101.5 |
| | 2 | 620.70 | 615.70 | 100.8 | 3919.98 | 3761.6 | 104.2 |
| | 3 | 622.21 | 616.10 | 101.0 | 3930.48 | 3889.2 | 101.1 |
| | 4 | 622.89 | 634.00 | 98.2 | 3871.86 | 3947.9 | 98.1 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | FCADW | | | FBQ | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1970 | 1 | 632.06 | 642.20 | 98.4 | 4049.43 | 4117.9 | 98.3 |
| | 2 | 636.52 | 645.60 | 98.6 | 4013.49 | 4139.3 | 97.0 |
| | 3 | 638.65 | 624.60 | 102.3 | 4045.97 | 4133.9 | 97.9 |
| | 4 | 628.94 | 642.60 | 97.9 | 3997.87 | 4131.3 | 96.8 |
| 1971 | 1 | 638.16 | 639.50 | 99.8 | 4075.21 | 4142.3 | 98.4 |
| | 2 | 637.13 | 637.10 | 100.0 | 4111.97 | 4156.2 | 98.9 |
| | 3 | 636.45 | 624.20 | 102.0 | 4117.71 | 4269.4 | 96.4 |
| | 4 | 630.67 | 637.00 | 99.0 | 7217.12 | 4092.2 | 103.1 |
| 1972 | 1 | 637.36 | 636.70 | 100.1 | 4314.55 | 4259.1 | 101.3 |
| | 2 | 637.70 | 638.30 | 99.9 | 4356.19 | 4450.8 | 97.9 |
| | 3 | 638.96 | 638.10 | 100.1 | 4508.56 | 4564.2 | 98.8 |
| | 4 | 639.34 | 656.20 | 97.4 | 4467.98 | 4606.9 | 97.0 |
| 1973 | 1 | 648.61 | 642.30 | 101.0 | 4543.82 | 4387.8 | 103.6 |
| | 2 | 642.34 | 641.70 | 100.1 | 4382.14 | 4189.6 | 104.6 |
| | 3 | 642.53 | 654.70 | 98.1 | 4423.84 | 4061.9 | 108.9 |
| | 4 | 649.32 | 669.70 | 97.0 | 4223,43 | 4491.2 | 94.0 |
| 1974 | 1 | 657.09 | 669.3 | 98.2 | 4026.79 | 4179.8 | 96.3 |
| | 2 | 657.38 | 666.5 | 98.6 | 3892.8 | 4343.7 | 89.6 |
| | 3 | 656.50 | 652.2 | 100.7 | 3793.10 | 3762.1 | 100.8 |
| | 4 | 650.03 | | | 3605.77 | | |
| 1975 | 1 | 649.46 | | | 3392.53 | | |
| | 2 | 649.67 | | | 3991.00 | | |
| | 3 | 650.25 | | | 4451.31 | | |
| | 4 | 651.01 | | | 4689.16 | | |
| 1976 | 1 | 651.86 | | | 4205.41 | | |
| | 2 | 652.75 | | | 4544.23 | | |
| | 3 | 653.67 | | | 5037.66 | | |
| | 4 | 654.59 | | | 5297.80 | | |
| 1977 | 1 | 655.52 | | | 4834.64 | | |
| | 2 | 656.46 | | | 5168.03 | | |
| | 3 | 657.39 | | | 5753.84 | | |
| | 4 | 658.32 | | | 5975.95 | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CULS | | | CAVS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1967 | 1 | 1,675 | 1,797 | 93.2 | 1,569 | 1,573 | 99.8 |
| | 2 | 1,715 | 1,630 | 105.2 | 1,365 | 1,358 | 100.5 |
| | 3 | 1,903 | 1,829 | 104.0 | 1,458 | 1,446 | 99.7 |
| | 4 | 1,699 | 1,968 | 86.3 | 1,550 | 1,556 | 98.2 |
| 1968 | 1 | 1,609 | 1,735 | 92.8 | 1,413 | 1,440 | 98.4 |
| | 2 | 1,706 | 1,645 | 103.7 | 1,244 | 1,265 | 103.5 |
| | 3 | 1,862 | 1,970 | 94.5 | 1,354 | 1,309 | 98.2 |
| | 4 | 1,783 | 2,039 | 87.4 | 1,403 | 1,429 | 96.6 |
| 1969 | 1 | 1,693 | 1,798 | 94.2 | 1,301 | 1,347 | 95.9 |
| | 2 | 1,770 | 1,749 | 101.2 | 1,066 | 1,112 | 103.7 |
| | 3 | 1,882 | 1,985 | 94.8 | 1,224 | 1,180 | 101.1 |
| | 4 | 1,798 | 1,994 | 90.2 | 1,233 | 1,219 | 96.6 |
| 1970 | 1 | 1,700 | 1,635 | 104.0 | 1,059 | 1,096 | 95.8 |
| | 2 | 1,653 | 1,577 | 104.8 | 913 | 953 | 105.8 |
| | 3 | 1,778 | 1,701 | 104.5 | 1,049 | 992 | 105.0 |
| | 4 | 1,589 | 1,781 | 89.2 | 1,083 | 1,032 | 105.3 |
| 1971 | 1 | 1,638 | 1,632 | 100.4 | 1,059 | 1,006 | 105.3 |
| | 2 | 1,744 | 1,750 | 99.6 | 777 | 882 | 88.1 |
| | 3 | 1,920 | 1,794 | 107.0 | 961 | 889 | 108.1 |
| | 4 | 1,615 | 1,824 | 88.6 | 944 | 911 | 103.7 |
| 1972 | 1 | 1,615 | 1,666 | 96.9 | 890 | 885 | 100.6 |
| | 2 | 1,694 | 1,641 | 103.2 | 626 | 699 | 89.5 |
| | 3 | 1,753 | 1,653 | 106.1 | 749 | 718 | 104.4 |
| | 4 | 1,501 | 1,679 | 89.4 | 818 | 751 | 108.9 |
| 1973 | 1 | 1,642 | 1,745 | 94.1 | 651 | 685 | 95.0 |
| | 2 | 1,850 | 1,594 | 116.1 | 489 | 490 | 100.0 |
| | 3 | 1,651 | 1,714 | 96.3 | 516 | 477 | 108.1 |
| | 4 | 1,399 | 1,863 | 75.1 | 662 | 601 | 110.1 |
| 1974 | 1 | 1,866 | 1,854 | 100.6 | 685 | 672 | 101.9 |
| | 2 | 2,027 | 1,570 | 129.1 | 489 | 584 | 83.7 |
| | 3 | 1,942 | 2,157 | 90.1 | 657 | 761 | 86.3 |
| | 4 | 2,070 | | | 773 | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CULS | | | CAVS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1975 | 1 | 1,936 | | | 740 | | |
| | 2 | 2,069 | | | 513 | | |
| | 3 | 1,991 | | | 586 | | |
| | 4 | 1,786 | | | 630 | | |
| 1976 | 1 | 2,155 | | | 615 | | |
| | 2 | 2,432 | | | 404 | | |
| | 3 | 2,195 | | | 487 | | |
| | 4 | 1,944 | | | 539 | | |
| 1977 | 1 | 2,462 | | | 500 | | |
| | 2 | 2,887 | | | 292 | | |
| | 3 | 2,492 | | | 378 | | |
| | 4 | 2,176 | | | 431 | | |
| | | | TNFCM | | | NFADW | |
| 1967 | 1 | 4,348 | 4,528 | 96.0 | 395.8 | 394.6 | 100.3 |
| | 2 | 4,272 | 4,177 | 102.3 | 411.8 | 410.6 | 100.3 |
| | 3 | 4,569 | 4,539 | 100.7 | 400.2 | 407.3 | 98.3 |
| | 4 | 4,400 | 4,632 | 95.0 | 289.6 | 396.0 | 98.4 |
| 1968 | 1 | 3,927 | 4,099 | 95.8 | 396.1 | 398.1 | 99.5 |
| | 2 | 3,866 | 3,863 | 100.1 | 410.9 | 407.6 | 100.8 |
| | 3 | 3,194 | 4,398 | 95.4 | 398.7 | 412.8 | 96.6 |
| | 4 | 4,146 | 4,476 | 92.6 | 394.2 | 398.0 | 99.0 |
| 1969 | 1 | 3,689 | 3,825 | 96.5 | 398.4 | 395.4 | 100.7 |
| | 2 | 3,509 | 3,457 | 101.5 | 418.1 | 306.5 | 102.8 |
| | 3 | 3,765 | 3,968 | 94.9 | 397.9 | 409.7 | 97.1 |
| | 4 | 3,848 | 3,989 | 96.5 | 400.6 | 413.7 | 96.8 |
| 1970 | 1 | 3,278 | 3,199 | 102.5 | 408.4 | 406.7 | 100.4 |
| | 2 | 3,156 | 3,144 | 100.4 | 424.5 | 421.0 | 100.8 |
| | 3 | 3,477 | 3,322 | 104.7 | 407.2 | 426.9 | 95.4 |
| | 4 | 3,314 | 3,490 | 95.0 | 398.3 | 419.7 | 94.9 |
| 1971 | 1 | 3,155 | 3,111 | 101.4 | 403.8 | 414.9 | 97.3 |
| | 2 | 3,012 | 3,269 | 92.1 | 440.7 | 434.0 | 101.5 |
| | 3 | 3,558 | 3,326 | 107.0 | 422.2 | 431.6 | 97.8 |
| | 4 | 3,168 | 3,290 | 96.3 | 409.6 | 428.8 | 95.5 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | TNFCM | | | NFADW | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1972 | 1 | 3,849 | 2,895 | 98.4 | 412.5 | 424.5 | 97.2 |
| | 2 | 2,653 | 2,749 | 96.5 | 454.8 | 443.5 | 102.6 |
| | 3 | 2,869 | 2,580 | 11.2 | 427.1 | 426.3 | 100.2 |
| | 4 | 2,696 | 2,773 | 97.2 | 407.4 | 439.3 | 92.7 |
| 1973 | 1 | 2,414 | 2,512 | 96.1 | 432.2 | 438.8 | 98.5 |
| | 2 | 2,537 | 2.102 | 120.7 | 491.1 | 445.0 | 110.4 |
| | 3 | 2,263 | 2,261 | 100.1 | 448.7 | 446.3 | 100.5 |
| | 4 | 2,537 | 2,756 | 85.5 | 417.7 | 448.8 | 93.1 |
| 1974 | 1 | 2,906 | 2,941 | 98.8 | 452.9 | 454.7 | 99.6 |
| | 2 | 3,104 | 2,884 | 107.6 | 536.6 | 477.6 | 112.4 |
| | 3 | 3,489 | 4,356 | 80.1 | 484.7 | 484.4 | 100.1 |
| | 4 | 4,056 | | | 483.1 | | |
| 1975 | 1 | 3,790 | | | 486.8 | | |
| | 2 | 3,353 | | | 543.7 | | |
| | 3 | 3,026 | | | 478.9 | | |
| | 4 | 2,804 | | | 452.1 | | |
| 1976 | 1 | 3,249 | | | 493.1 | | |
| | 2 | 3,061 | | | 584.2 | | |
| | 3 | 2,603 | | | 485.9 | | |
| | 4 | 2,493 | | | 459.0 | | |
| 1977 | 1 | 3,004 | | | 520.9 | | |
| | 2 | 2,877 | | | 671.6 | | |
| | 3 | 2,229 | | | 505.9 | | |
| | 4 | 2,926 | | | 479.9 | | |
| | | | NFBQ | | | IMPUS | |
| 1967 | 1 | 1720.8 | 1786.9 | 96.3 | 1380.8 | 1327.7 | 104.0 |
| | 2 | 1747.7 | 1715.0 | 101.9 | | | |
| | 3 | 1820.6 | 1848.9 | 98.5 | | | |
| | 4 | 1705.6 | 1834.4 | 93.0 | | | |
| 1968 | 1 | 1552.4 | 1631.7 | 95.1 | 1633.8 | 1518.0 | 107.6 |
| | 2 | 1580.8 | 1574.4 | 100.4 | | | |
| | 3 | 1661.1 | 1815.6 | 91.5 | | | |
| | 4 | 1621.2 | 1781.5 | 91.0 | | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | NFBQ | | | IMPUS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1969 | 1 | 1466.6 | 1512.3 | 97.0 | 1752.9 | 1640.5 | 106.9 |
| | 2 | 1469.3 | 1405.4 | 104.5 | | | |
| | 3 | 1482.8 | 1625.8 | 91.2 | | | |
| | 4 | 1528.3 | 1650.1 | 92.6 | | | |
| 1970 | 1 | 1341.3 | 1301.1 | 103.1 | 1929.1 | 1815.7 | 106.2 |
| | 2 | 1349.9 | 1323.7 | 102.0 | | | |
| | 3 | 1393.2 | 1418.1 | 98.2 | | | |
| | 4 | 1284.4 | 1464.7 | 87.7 | | | |
| 1971 | 1 | 1265.4 | 1290.7 | 98.0 | 1699.5 | 1755.5 | 96.8 |
| | 2 | 1355.8 | 1418.8 | 95.6 | | | |
| | 3 | 1483.9 | 1435.6 | 103.4 | | | |
| | 4 | 1271.6 | 1410.8 | 90.1 | | | |
| 1972 | 1 | 1169.5 | 1228.9 | 95.2 | 1752.4 | 1996.3 | 87.8 |
| | 2 | 1260.3 | 1219.2 | 103.4 | | | |
| | 3 | 1202.9 | 1099.8 | 109.3 | | | |
| | 4 | 1064.0 | 1218.1 | 87.4 | | | |
| 1973 | 1 | 1060.0 | 1102.2 | 96.2 | 2301.5 | 2020 | 113.9 |
| | 2 | 1351.8 | 935.4 | 144.5 | | | |
| | 3 | 1032.3 | 1009.1 | 102.3 | | | |
| | 4 | 936.0 | 1236.8 | 75.7 | | | |
| 1974 | 1 | 1343.5 | 1337.2 | 100.5 | 1440.3 | 1645 | 87.6 |
| | 2 | 1780.6 | 1377.3 | 129.3 | | | |
| | 3 | 1680.4 | 2109.9 | 79.6 | | | |
| | 4 | 1976.6 | | | | | |
| 1975 | 1 | 1895.5 | | | 932.8 | | |
| | 2 | 1960.0 | | | | | |
| | 3 | 1529.2 | | | | | |
| | 4 | 1315.5 | | | | | |
| 1976 | 1 | 1696.5 | | | 660.9 | | |
| | 2 | 2018.6 | | | | | |
| | 3 | 1383.8 | | | | | |
| | 4 | 1217.1 | | | | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | NFBQ | | | IMPUS | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1977 | 1 | 1719.5 | | | 944.3 | | |
| | 2 | 2334.4 | | | | | |
| | 3 | 1314.5 | | | | | |
| | 4 | 1201.8 | | | | | |
| | | | FBC | | | NFBC | |
| 1967 | 1 | 1332.0 | 3254.6 | 96.2 | 1928.3 | 1994.4 | 96.7 |
| | 2 | 3280.2 | 3448.5 | 95.1 | 1915.3 | 1882.5 | 101.7 |
| | 3 | 3282.6 | 3221.6 | 101.9 | 2141.1 | 2169.4 | 98.7 |
| | 4 | 3194.3 | 3164.1 | 101.0 | 1962.1 | 2090.9 | 93.8 |
| 1968 | 1 | 3303.4 | 3443.5 | 94.6 | 1792.9 | 1872.2 | 95.8 |
| | 2 | 3492.3 | 3555.6 | 98.2 | 1839.8 | 1833.4 | 100.3 |
| | 3 | 3530.4 | 3573.4 | 98.8 | 2051.1 | 2205.6 | 93.0 |
| | 4 | 3621.4 | 3538.0 | 102.4 | 1927.7 | 2088.0 | 92.3 |
| 1969 | 1 | 3761.9 | 3704.2 | 101.6 | 1731.1 | 1776.8 | 97.4 |
| | 2 | 3816.5 | 3658.1 | 104.3 | 1779.8 | 1715.9 | 103.7 |
| | 3 | 3854.5 | 3813.2 | 101.1 | 1977.8 | 2120.8 | 93.3 |
| | 4 | 3790.4 | 3866.4 | 98.0 | 1828.8 | 1950.6 | 93.8 |
| 1970 | 1 | 3964.9 | 4033.4 | 93.3 | 1784.8 | 1744.6 | 102.3 |
| | 2 | 3916.9 | 4042.8 | 96.9 | 1640.4 | 1614.2 | 101.6 |
| | 3 | 3956.9 | 4053.9 | 97.8 | 1865.2 | 1690.1 | 110.4 |
| | 4 | 3923.4 | 4056.8 | 96.7 | 1662.9 | 1843.2 | 90.2 |
| 1971 | 1 | 3994.2 | 4061.3 | 98.3 | 1580.4 | 1605.7 | 98.4 |
| | 2 | 4012.5 | 4056.7 | 98.9 | 1705.3 | 1768.3 | 96.4 |
| | 3 | 4047.2 | 4198.9 | 96.4 | 2006.4 | 1958.1 | 102.5 |
| | 4 | 4147.1 | 4022.2 | 103.1 | 1640.6 | 1779.8 | 92.2 |
| 1972 | 1 | 4239.6 | 4184.1 | 101.3 | 1520.5 | 1579.9 | 96.2 |
| | 2 | 4281.2 | 4375.8 | 97.8 | 1668.3 | 1627.2 | 102.5 |
| | 3 | 4453.6 | 4509.2 | 98.8 | 1794.3 | 1691.8 | 106.1 |
| | 4 | 4400.98 | 4539.9 | 96.9 | 1558.0 | 1712.1 | 91.0 |
| 1973 | 1 | 4475.82 | 4319.8 | 103.6 | 1468.0 | 1510.2 | 97.2 |
| | 2 | 4314.6 | 4122.1 | 104.7 | 1766.3 | 1349.9 | 130.8 |
| | 3 | 4368.8 | 4006.9 | 109.0 | 1566.3 | 1543.1 | 101.5 |
| | 4 | 4147.4 | 4415.2 | 93.9 | 1485.0 | 1785.8 | 83.2 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | FBC | | | NFBC | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1974 | 1 | 3975.2 | 4128.2 | 96.3 | 1794.9 | 1788.7 | 100.4 |
| | 2 | 3840.3 | 4291.2 | 89.5 | 2152.6 | 1749.3 | 123.1 |
| | 3 | 3722.2 | 3691.2 | 100.8 | 2039.4 | 2468.9 | 82.6 |
| | 4 | 3538.8 | | | 1944.9 | | |
| 1975 | 1 | 3317.7 | | | 1856.3 | | |
| | 2 | 3915.7 | | | 1920.7 | | |
| | 3 | 4380.4 | | | 1494.7 | | |
| | 4 | 4620.6 | | | 1283.8 | | |
| 1976 | 1 | 4128.9 | | | 1657.3 | | |
| | 2 | 4467.3 | | | 1979.3 | | |
| | 3 | 4965.1 | | | 1349.3 | | |
| | 4 | 5227.7 | | | 1185.4 | | |
| 1977 | 1 | 4756.6 | | | 1680.3 | | |
| | 2 | 5089.5 | | | 2295.1 | | |
| | 3 | 5679.7 | | | 1279.9 | | |
| | 4 | 5904.3 | | | 1170.1 | | |
| | | FBPW | | | NFBPW | | |
| 1967 | 1 | 42.56 | 39.14 | 108.7 | 34.03 | 32.47 | 104.8 |
| | 2 | 41.78 | 40.15 | 104.1 | 33.52 | 33.83 | 99.1 |
| | 3 | 43.33 | 43.18 | 100.4 | 33.38 | 33.67 | 99.2 |
| | 4 | 43.51 | 42.08 | 103.4 | 32.67 | 31.29 | 104.4 |
| 1968 | 1 | 46.56 | 42.89 | 108.6 | 36.58 | 34.12 | 107.2 |
| | 2 | 44.83 | 43.13 | 103.9 | 36.37 | 35.99 | 101.1 |
| | 3 | 44.04 | 44.52 | 98.9 | 34.53 | 35.36 | 97.6 |
| | 4 | 41.14 | 44.62 | 92.2 | 32.59 | 33.26 | 98.0 |
| 1969 | 1 | 46.48 | 46.34 | 100.3 | 38.04 | 36.88 | 103.2 |
| | 2 | 47.13 | 50.91 | 92.6 | 39.55 | 40.34 | 97.9 |
| | 3 | 46.61 | 48.46 | 96.2 | 38.56 | 39.77 | 96.9 |
| | 4 | 46.33 | 44.60 | 103.9 | 39.03 | 37.82 | 103.2 |
| 1970 | 1 | 48.53 | 37.66 | 101.8 | 41.81 | 41.98 | 99.6 |
| | 2 | 49.79 | 47.99 | 103.8 | 43.96 | 41.12 | 106.9 |
| | 3 | 50.01 | 48.77 | 102.5 | 41.25 | 39.26 | 105.1 |
| | 4 | 49.88 | 44.85 | 111.2 | 38.94 | 37.09 | 105.0 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | FBPW | | | NFBPW | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1971 | 1 | 53.69 | 50.64 | 106.0 | 42.31 | 40.41 | 104.7 |
| | 2 | 54.70 | 53.06 | 103.1 | 43.74 | 41.44 | 105.5 |
| | 3 | 55.67 | 53.09 | 104.9 | 42.17 | 41.02 | 102.8 |
| | 4 | 51.26 | 53.87 | 95.2 | 41.37 | 41.16 | 100.5 |
| 1972 | 1 | 56.89 | 56.67 | 100.4 | 45.84 | 44.86 | 102.2 |
| | 2 | 56.55 | 56.51 | 100.1 | 47.46 | 45.85 | 103.5 |
| | 3 | 57.22 | 55.54 | 103.0 | 46.03 | 46.93 | 98.1 |
| | 4 | 56.51 | 53.80 | 105.0 | 46.85 | 46.24 | 101.3 |
| 1973 | 1 | 63.22 | 66.36 | 95.3 | 52.93 | 57.04 | 92.8 |
| | 2 | 66.76 | 69.97 | 95.4 | 55.05 | 61.37 | 89.7 |
| | 3 | 71.08 | 70.80 | 100.4 | 58.73 | 62.91 | 93.3 |
| | 4 | 73.31 | 64.18 | 114.2 | 61.51 | 55.93 | 110.0 |
| 1974 | 1 | 84.12 | 72.99 | 115.2 | 69.69 | 60.05 | 125.0 |
| | 2 | 91.02 | 64.72 | 140.6 | 73.80 | 49.64 | 146.5 |
| | 3 | 99.67 | 70.82 | 140.7 | 79.75 | 45.13 | 141.4 |
| | 4 | 77.05 | | | 62.04 | | |
| 1975 | 1 | 84.73 | | | 67.58 | | |
| | 2 | 78.13 | | | 65.00 | | |
| | 3 | 74.51 | | | 64.24 | | |
| | 4 | 68.05 | | | 60.18 | | |
| 1976 | 1 | 83.64 | | | 71.38 | | |
| | 2 | 80.73 | | | 69.63 | | |
| | 3 | 76.44 | | | 68.77 | | |
| | 4 | 70.01 | | | 63.18 | | |
| 1977 | 1 | 84.34 | | | 72.34 | | |
| | 2 | 81.52 | | | 69.42 | | |
| | 3 | 76.92 | | | 70.13 | | |
| | 4 | 70.94 | | | 64.33 | | |
| | | | CSP | | | CFSP | |
| 1967 | 1 | 26.07 | 24.15 | 108.0 | 29.32 | 27.76 | 105.6 |
| | 2 | 25.62 | 24.63 | 104.0 | 29.75 | 28.32 | 105.0 |
| | 3 | 26.78 | 26.73 | 100.2 | 29.63 | 28.57 | 103.7 |
| | 4 | 26.09 | 25.72 | 101.5 | 29.19 | 27.35 | 106.7 |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CSP | | | CFSP | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1968 | 1 | 28.22 | 26.13 | 108.0 | 30.95 | 27.59 | 112.2 |
| | 2 | 27.32 | 26.37 | 103.6 | 30.77 | 29.77 | 103.4 |
| | 3 | 27.14 | 27.50 | 98.7 | 30.26 | 29.82 | 101.5 |
| | 4 | 24.78 | 25.53 | 97.1 | 28.62 | 29.22 | 97.9 |
| 1969 | 1 | 28.40 | 28.15 | 100.9 | 32.64 | 30.51 | 107.0 |
| | 2 | 29.38 | 32.53 | 90.3 | 34.09 | 35.12 | 97.1 |
| | 3 | 29.45 | 30.24 | 97.4 | 33.53 | 33.23 | 100.9 |
| | 4 | 28.58 | 27.79 | 102.8 | 32.28 | 32.70 | 98.7 |
| 1970 | 1 | 30.20 | 29.50 | 102.4 | 35.29 | 35.70 | 98.9 |
| | 2 | 31.01 | 30.15 | 102.9 | 38.15 | 38.59 | 98.9 |
| | 3 | 31.17 | 30.19 | 103.2 | 38.85 | 37.79 | 102.8 |
| | 4 | 30.35 | 27.53 | 110.2 | 38.07 | 34.85 | 109.2 |
| 1971 | 1 | 32.82 | 31.05 | 105.7 | 39.32 | 35.24 | 111.6 |
| | 2 | 33.71 | 32.57 | 103.5 | 39.92 | 36.27 | 110.1 |
| | 3 | 34.50 | 32.76 | 105.3 | 38.70 | 36.91 | 104.8 |
| | 4 | 31.23 | 33.47 | 93.3 | 37.00 | 38.54 | 96.0 |
| 1972 | 1 | 35.45 | 35.69 | 99.3 | 42.35 | 42.31 | 100.1 |
| | 2 | 36.23 | 36.02 | 100.6 | 45.37 | 46.37 | 97.9 |
| | 3 | 37.30 | 36.24 | 102.9 | 46.98 | 48.64 | 96.6 |
| | 4 | 36.73 | 35.07 | 104.7 | 48.58 | 48.89 | 99.4 |
| 1973 | 1 | 41.41 | 43.17 | 95.9 | 53.82 | 55.83 | 96.4 |
| | 2 | 44.11 | 46.00 | 95.9 | 58.64 | 62.05 | 94.5 |
| | 3 | 47.88 | 49.04 | 97.6 | 61.96 | 65.93 | 94.0 |
| | 4 | 47.42 | 40.19 | 118.0 | 63.21 | 53.15 | 114.6 |
| 1974 | 1 | 54.28 | 45.39 | 119.6 | 64.14 | 52.72 | 121.7 |
| | 2 | 57.39 | 39.52 | 145.2 | 65.55 | 40.47 | 162.0 |
| | 3 | 63.18 | 44.21 | 142.9 | 62.07 | 34.15 | 181.8 |
| | 4 | 50.21 | | | 47.00 | | |
| 1975 | 1 | 55.18 | | | 57.22 | | |
| | 2 | 51.00 | | | 59.06 | | |
| | 3 | 48.75 | | | 56.93 | | |
| | 4 | 43.74 | | | 51.27 | | |

| Year and quarter | | Variable code name | | | | | |
|---|---|---|---|---|---|---|---|
| | | CSP | | | CFSP | | |
| | | Est. | Obs. | EI | Est. | Obs. | EI |
| 1976 | 1 | 53.13 | | | 59.67 | | |
| | 2 | 51.39 | | | 62.80 | | |
| | 3 | 48.87 | | | 60.00 | | |
| | 4 | 44.22 | | | 56.30 | | |
| 1977 | 1 | 53.48 | | | 63.88 | | |
| | 2 | 51.79 | | | 66.15 | | |
| | 3 | 49.08 | | | 62.47 | | |
| | 4 | 44.71 | | | 58.5 | | |
| | | | CUP | | | | |
| 1967 | 1 | 17.53 | 17.15 | 102.2 | | | |
| | 2 | 17.76 | 17.81 | 99.7 | | | |
| | 3 | 17.47 | 17.79 | 98.2 | | | |
| | 4 | 16.89 | 16.15 | 104.6 | | | |
| 1968 | 1 | 18.73 | 17.42 | 107.5 | | | |
| | 2 | 19.02 | 18.67 | 101.9 | | | |
| | 3 | 18.01 | 18.46 | 97.6 | | | |
| | 4 | 16.95 | 17.20 | 98.6 | | | |
| 1969 | 1 | 19.62 | 18.62 | 105.4 | | | |
| | 2 | 20.91 | 21.49 | 97.3 | | | |
| | 3 | 20.61 | 21.18 | 97.3 | | | |
| | 4 | 20.61 | 19.87 | 103.7 | | | |
| 1970 | 1 | 21.92 | 22.12 | 99.1 | | | |
| | 2 | 23.45 | 22.82 | 102.8 | | | |
| | 3 | 22.21 | 20.82 | 106.7 | | | |
| | 4 | 20.48 | 19.55 | 104.7 | | | |
| 1971 | 1 | 22.03 | 21.00 | 104.9 | | | |
| | 2 | 23.25 | 21.94 | 106.0 | | | |
| | 3 | 22.35 | 21.75 | 102.7 | | | |
| | 4 | 21.85 | 21.80 | 100.2 | | | |
| 1972 | 1 | 24.37 | 23.71 | 102.8 | | | |
| | 2 | 25.95 | 25.40 | 102.2 | | | |
| | 3 | 25.57 | 26.32 | 97.2 | | | |
| | 4 | 26.19 | 25.32 | 103.1 | | | |

| Year and quarter | | Variable code name | | |
|---|---|---|---|---|
| | | CUP | | |
| | | Est. | Obs. | EI |
| 1973 | 1 | 29.08 | 30.67 | 94.8 |
| | 2 | 30.64 | 33.65 | 91.0 |
| | 3 | 33.03 | 35.45 | 93.2 |
| | 4 | 33.85 | 31.50 | 107.5 |
| 1974 | 1 | 38.05 | 31.95 | 119.1 |
| | 2 | 39.30 | 28.19 | 139.4 |
| | 3 | 43.14 | 23.77 | 181.5 |
| | 4 | 34.06 | | |
| 1975 | 1 | 37.03 | | |
| | 2 | 36.14 | | |
| | 3 | 35.66 | | |
| | 4 | 33.25 | | |
| 1976 | 1 | 38.54 | | |
| | 2 | 38.03 | | |
| | 3 | 37.53 | | |
| | 4 | 34.50 | | |
| 1977 | 1 | 39.17 | | |
| | 2 | 37.98 | | |
| | 3 | 38.29 | | |
| | 4 | 35.15 | | |