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Economic impacts of the Farmer-Owned Reserve program on the U.S. corn-livestock sector

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ECONOMIC IMPACTS OF THE FARMER-OWNED RESERVE PROGRAM ON THE U.S. CORN-LIVESTOCK SECTOR

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Economic impacts of the Farmer-Owned Reserve

program on the U.S. corn-livestock sector

by

Donald Craig Smyth

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CHAPTER I. INTRODUCTION

As perhaps the most comprehensive piece of farm legislation since the 1930s, the Food and Agriculture Act of 1977 marked the beginning of a new approach toward grains policy. With the creation of the Farmer-Owned Reserve program, emphasis was shifted toward grain reserves as the primary policy instrument and away from price supports and supply control, where publically controlled stocks were only a residual of the grains policy.

The innovations provided under the 1977 act were primarily outgrowths of responses to the upheavals in commodity markets during the early 1970s. Events during this period significantly changed the nature of world grain markets. The major developments included a sharp increase in petroleum prices, a movement among larger trading nations from fixed to flexible exchange rates, a change in Soviet import policy, production variability around the world, and the increased reliance of the U.S. on agricultural exports in the wake of a rising use of insulating trade policies by other countries. These events fostered a sharp increase in price variability, which together with changes in the economic and political situation in rural America, were instrumental forces in motivating the introduction and passage of the Farmer-Owned Reserve (FOR) program.

Although the goals of the FOR program have never been explicitly stated, the program is assumed to have the dual objectives of price stabilization and price support. The primary emphasis is presumably on "partially" stabilizing prices. That is, the program operates with the intention of increasing the probability that market prices will fall within

a pre-established price range, rather than stabilizing prices around a target.

Although the pursuit of these objectives takes place through a complex set of program features, the economics of FOR operation are relatively simple. Through the program's offering of low interest loans and storage subsidies at low prices, producers are encouraged to reduce marketings and hold more grain in storage than they would otherwise. The removal of these benefits at high prices, and the possible imposition of certain penalties for continued grain storage, induces producers to release these quantities to the market. The accumulation and release of "reserve" stocks in this fashion, buffers the impact of demand and supply side instabilities, thereby reducing price variation.

Since its inception, the Farmer-Owned Reserve has become a massive and quite variable component of the commodity market structure. FOR stocks of corn, for example, have fluctuated from 185 million bushels in 1981, to over 2.7 billion bushels in 1983, constituting 3 percent and 33 percent of total production, respectively. A program of such magnitude and variability has obvious and important implications, not only for the eligible crops, but for related crops and the livestock industry as well.

Purpose of the Study

This study entails an econometric investigation of the market impacts of the FOR program for corn. The approach focuses on assessing some of the price-quantity impacts of the program on the markets of the corn-livestock sector. While the strongest focus is on corn markets, the livestock subsector is included in the study because of the strong interdependencies

that exist between the two, and because as Breimyer and Rhodes (1975) point out, policy measures designed for one part of the subsector may have substantial and unintended effects upon other, closely interrelated parts.

Because the primary goal of the FOR program is the stabilization of prices for the eligible crops, the main objective in the study is to examine the success of the program in achieving a reduction in corn price variation over time. The issue is taken up in a seasonal framework, so that the stabilizing characteristics of the program can be evaluated in both intrayear and interyear terms. Secondary objectives of the study include examining the program's effects on corn price levels, disappearance and carryover stocks, and livestock prices and variability.

A quarterly econometric modeling approach is employed as the means of identifying the specific market impacts of the program. The equations of the model embody the supply and demand sides of the corn, fed beef, pork, and broiler markets. Simulation of the model over the period 1971IV–1982IV under both the FOR policy and an alternative storage strategy, are conducted for the purpose of contrasting the behavior of the relevant markets when conditioned by the two strategies.

Organization of the Study

The study is organized into nine chapters which are intended to provide a systematic approach to investigating the problems outlined above.

The remainder of this chapter is devoted to a brief review of previous studies which are directly concerned with operational or performance issues of the Farmer-Owned Reserve program. Presented in the first section is an overview of the more important evaluative studies of the market impacts and

performance of the program. Following this is a summary of other research works focusing on partial aspects of the program which are considered relevant to the study.

Chapter II takes up the issue of market instability as a policy problem, and the role of publically operated buffer stocks in U.S. agricultural policy. The mechanics of buffer stock operation, as well as operational considerations in buffer stock management are highlighted.

The major provisions of the Farmer-Owned Reserve program for corn are summarized in Chapter III, followed by a brief review of reserve operations for the years, 1977-1983.

A theoretical discussion of the influence of the program on price variability is taken up in Chapter IV. In a comparative statics framework, the price moderating ability of the program is examined. A section of the chapter is also devoted to a discussion of the interaction of reserve stocks with privately held free stocks of grain. As is widely recognized, the extent of this interaction has noteworthy implications for the performance of the program.

Chapter V contains a descriptive summary of the structure of the U.S. corn-livestock subsector. As Johnson and Rausser (1977) point out, study of the underlying system of interest should precede consideration of model construction. As such, attention is focused on the structure of the subsector and identifying the interrelations between its components, as a basis for the specification of an econometric model of the subsector.

A comprehensive econometric model of the corn-livestock subsector is presented in Chapter VI. Conceptualization of the model is based on

standard microeconomic theory with recognition of the specific biological and market characteristics of the respective commodities. Discussion of the specification of the model and the estimation results for the stochastic equations are presented in detail.

Validation tests of the model are conducted in Chapter VII. The simulation performance, as well as stabilizing characteristics of the model are checked by historical and ex post model forecasts, and by multiplier analysis.

Chapter VIII presents the empirical analysis of the Farmer-Owned Reserve program. Two models are formulated -- one describing the structure of the relevant markets under the FOR program, and one describing the markets under an alternative storage policy designed to replicate the stock management strategies prior to implementation of the FOR in 1977. Solutions generated for the two models over the period corresponding to the first five years of the FOR program provide the basis for examining the market implications of the program relative to continuation of the pre-1977 policies.

The analysis concludes with a brief summary of the study in Chapter IX.

Review of Selected Studies

Several studies have sought to determine the market implications of the FOR program. In a variety of contexts, the program has been judged with respect to its effects on such factors as grain and livestock price levels and variability, total carryover stocks, producer income variability, and government expenditures. A brief overview of the major empirical studies is presented, with discussion confined primarily to the methods of

analysis, and the results reached significant to this study. For comparative purposes, the methodologies of these studies are summarized in Table 1.1.

Sharples

An initial evaluation of the program was conducted by Sharples (1980). Policies affecting wheat markets prior to, and since 1977 were compared in their abilities to meet a set of six conflicting policy objectives including improved price stability, higher and more stable producer incomes, reduced government expenditures and intervention, adequate reserves for foreign trade committments, and more consumer protection from very high prices. In the analysis, the pre-1977 wheat policy included deficiency payments, accumulation of wheat stocks when the market price fell below the loan, and release of those stocks when the price exceeded 115 percent of the loan. The post-1977 wheat policy differed by adding the FOR, and raising the release price of wheat stocks owned by the Commodity Credit Corporation (CCC) to 180 percent of the loan.

Using a computer simulation model of the U.S. wheat industry, the policy options were stochastically simulated over the seven crop years, 1977/78 to 1983/84, using a randomly selected series of shocks to U.S. wheat yield and exports. The results of interest indicated that relative to the pre-1977 policy, the post-1977 policy decreased wheat price variability, increased both the mean wheat price and privately-owned carryover stocks, and decreased government-held stocks. However, the analysis indicated that the post-1977 policy failed to significantly enhance producer incomes.

Table 1.1. Overview of major empirical studies of the Farmer-Owned Reserve Program

Author	Program commodity	Purpose of study	Model	Trea FOR
Sharples (1980)	wheat	contrast ability of alternative storage policies in meeting certain objectives	WHEATSIM[b] (nonestimated, annual)	endo
Meyers and Ryan (1981)	corn and wheat	estimate effects of FOR on prices, stocks, and production	five equation dynamic models (nonestimated, annual)	exog
Meyers, Womack and Bredahl (1981)	wheat	estimate effects of FOR on prices, stocks, utilization, and production	variation of Gallagher et al. (1981) model (annual)	endo
Gardner (1981a)	corn and wheat	estimate effects of FOR on prices and stocks	series of single equations (annual, quarterly)	exog
Just (1981)	corn and wheat	estimate effects of FOR on grain prices and stocks, and livestock prices and production	34 equation model of corn, wheat, livestock markets (quarterly)	exog
Morton (1982)	corn and wheat	estimate effects of FOR and alternative policies on grain and livestock prices	35 equation model of feedgrain, wheat, livestock markets (annual)	endo
Salathe, Price and Banker (1984)	all program commodities but rice	estimate effects of FOR on grain and livestock markets, farm income, and government costs	FAPSIM[c] (annual)	exog

[a]Bushel for bushel substitution of reserve stocks for free stocks used in the comm
[b]WHEATSIM is a simulation model of the U.S. wheat market, described in detail in b
[c]FAPSIM is a comprehensive model of the U.S. agricultural sector, discussed in Sa:

	Treatment of FOR stocks	Substitution coefficient[a]	Method of analysis
,	endogenous	-0.4 (assumed)	stochastic simulation of alternative policies over period 1977/78-1983/84, using randomly selected shocks to U.S. wheat yield and exports
s ,	exogenous	-0.2, -0.4 (assumed)	deterministic simulation of FOR and alternative policy for period 1977-1981, under both scenarios for substitution coefficients
al.	endogenous	-0.2 (estimated)	reduced form impact analysis of production and export shocks in 1978/79 and 1980/81
ıgle ınual,	exogenous	-0.74 wheat -0.61 corn (estimated)	graphical analysis and simple regressions for storage rules, and price dependent equations
ıodel ıt, :kets	exogenous	-0.81 wheat -0.52 corn (estimated)	deterministic simulation of estimated model, and estimated model with all FOR variables removed for period, 1977III-1979II
aodel , :ock ıal)	endogenous	-0.24 wheat -0.26 corn (estimated)	stochastic simulation of alternative policies over period 1981-1990, using randomly selected shocks to U.S. crop yields and exports
)	exogenous	-0.55 wheat -0.38 corn (estimated)	deterministic simulation of estimated model with all FOR variables removed, compared with actual market outcomes for 1977-1981

ed in the commercial inventory demand equations.
in detail in Holland and Sharples (1978).
scussed in Salathe, Price, and Gadson (1982).

Meyers and Ryan

Another preliminary assessment of the FOR program was performed by
Meyers and Ryan (1981). Employing an annual model of the U.S. corn and
wheat markets, the market influence of the FOR was examined relative to an
alternative policy utilizing only a nonrecourse loan program. To
investigate the hypothesis that the FOR moderates price movements, a five
equation dynamic model was constructed using assumed values for the price
elasticities and the FOR and CCC substitution coefficients for free stocks.
The results for the period 1978/79 to 1980/81 suggested that elimination of
the FOR would result in a larger price variance, lower total stocks, and
higher free stocks for both corn and wheat. Moreover, the FOR may have
slightly increased the average price for wheat, although the authors could
detect no significant effect of the program on average corn prices over the
three year period.

Meyers, Womack and Bredahl

Employing an annual model of the U.S. wheat market, Meyers et al.
(1981) were the first to endogenize reserve quantities of grain. In a
simple theoretical model, the authors show that the presence of reserve
stocks as both a demand shifter (via free stocks), and a price responsive
demand component, would increase the price elasticity of total demand if
the substitution coefficient of reserves for free stocks was in the range
(-1,0]. To investigate the hypothesis that the price impact of supply or
demand shocks was muted in the presence of the FOR, reduced form
multipliers were obtained from the structural model for both a production
shock and export shock induced in the 1977/78 and 1979/80 crop years. The

change in market behavior as a result of the FOR was evaluated by comparing

the impacts when reserves were endogenously determined, to when they were

fixed (corresponding to a no reserve situation, or a reserve filled to

capacity). The findings revealed that the FOR in the two periods acted as

a shock absorber, moderating price fluctuations. The shocks were absorbed

by changes in reserve stocks, increasing the variability of total stocks

while decreasing the variability of quantities flowing to the other

consumption channels.

Gardner

A relatively lengthy, but rather ad hoc evaluation of the program was

provided by Gardner (1981a). The methodologies used centered primarily on

graphical analysis in conjunction with single equation regressions in

examining the program's influence on annual, and quarterly grain stocks,

and annual, quarterly, and daily grain prices. The conclusions reached

contrasted sharply with those of previous studies. Gardner found that the

FOR had no significant direct effects on grain prices in the 1977 and 1978

marketing years, and had only a very small impact on total stocks.

Furthermore, FOR activities directed at short term price stabilization were

found to be largely unsuccessful.

Just

The first comprehensive econometric treatment of the subject was

conducted by Just (1981). The analysis was based on the deterministic

simulation of a 34 equation quarterly model of the wheat/feedgrain/

livestock economy. With exogenous reserve quantities, the model was

estimated for the two year period, 1977III to 1979II. Adding back the calculated residuals, the model was then simulated over the same period with all FOR variables removed. The generated data points were used to represent the market's response to actual conditions in the absence of the FOR program or any other price supporting policy. Using this approach, Just concluded that corn prices were supported by the FOR during the first year of the program, but quickly depressed in the second year. The finding was attributed to a maladjustment of the livestock industry to the reserve-influenced grain prices of the program's first year. Reserve-supported corn prices of 1977/78 allegedly led to a reduction in cattle placed on feed and in the number of hogs kept for market, thereby lowering the demand for feed and hence depressing corn prices in 1978/79.

To evaluate the ability of the FOR in moderating unexpected price shocks, the one quarter response of the markets (with and without the FOR) to the Soviet grain embargo of 1980 was also examined. The outcome indicated that the FOR did moderate the market shocks of the embargo. However, the author reminds that the result must be viewed in light of the fact that several changes in the program's provisions were deemed necessary immediately following the embargo to sufficiently cushion its impact. Hence, he concluded that "if the reserve policy were viewed as capable of handling large shocks in the grain market, then such major revisions in reserve parameters would not be required with such developments as the Russian grain embargo" (p. 82).

Morton

A stochastic simulation approach to examining the effect of alternative policies (with and without the FOR) on wheat, corn, and livestock price variability was undertaken by Morton (1982). Four alternative policies were imposed on a thirty-five equation, annual model of the wheat/feedgrain/livestock sector and stochastically simulated, using export and yield shocks, over the period 1981-1990. The policies included (1) a continuation of the 1977 policy, (2) a replacement of the FOR by a simple storage subsidy, (3) discontinuation of the set-aside authority, and (4) a free market case with no public intervention. To reflect expected management strategies, specific rules for set-aside decisions were imposed on the model at the beginning of each year's solution. Due to the limited number of annual observations, FOR behavior was not directly estimated, but approximated by linear response functions derived from actual data points. Using this approach, corn and wheat price variability (as measured by the respective means of the standard deviations from each of the simulated years) was found to be smallest under the 1977 (i.e., FOR) policy, and largest for the free market case. Morton found that variability in wheat prices increased over 300 percent in moving from the 1977 policy to the free market situation. Corn price variability, on the other hand, increased only 38 percent between the same two policies. With respect to the livestock markets, prices were also the most stable under the 1977 policy, although the 1977 policy was found to exert no significant effect on mean price levels over time.

Salathe, Price and Banker

Salathe et al. (1984) employed a large scale annual model of the U.S. agricultural sector (FAPSIM) to evaluate the reserve program for all program crops but rice. Removing all FOR variables, the authors simulated the model over the crop years 1977-1981, with the CCC release price maintained at its pre-program setting of 115 percent of the loan rate per commodity. Comparing the simulated no-reserve option with actual market outcomes, their results showed that the program significantly increased total stocks, in general had a positive impact on grain prices and mixed effects on price variability, depending on the commodity. The program also enhanced farm income while adding to total government outlays. With respect to corn markets, prices were increased up to 5 percent by the program and price variability was reduced by a very small amount. The minor influence of the program on price variability was attributed to the larger price band during the FOR period than before.

Other Studies

Several studies have addressed additional questions and issues raised by the FOR program. Although less comprehensive in nature these studies nonetheless focus on aspects of the program which are significant to this work.

An issue which receives lip service in virtually any study of the FOR is the interaction of the demand for free (or speculative) stocks with that of FOR stocks. The operations of the FOR program are not mutually exclusive of the storage activities of private speculators (Peck and Gray, 1980, p. 39), and the extent of this relationship has important

implications for the effectiveness of the FOR program. Meyers (1981) argued that the different substitution effects of reserve stocks for free stocks used in different studies of the FOR, may be one of the key reasons the results vary so considerably.

Sharples and Holland (1981) were among the few to empirically measure the substitution effect. Using a curvilinear functional form, the authors estimated a value for the substitution coefficient which they point out is likely not constant but positively related to price and FOR size. Nelson and Burnstein (1983), comparing the expected returns from alternative storage options, derive a demand for free stocks relation with and without the FOR. The authors show that as reserve stocks increase, the demand for free stocks shifts leftward. This shift has been attributed to an on-farm substitution effect (Meyers and Ryan, 1981), and an expectations effect (Sharples, 1982). However, in examining the interaction of reserves with free stocks, Gardner (1982) warns that it may be insufficient to discuss the relationship solely in terms of a tradeoff between the quantity of grain in the reserve program and the quantity of grain demanded for speculative purposes. He points out two other basic effects that should not be overlooked are the effect of the reserve program's rule for stock accumulation on the private trade's rule, and the effect of reserve stock levels under that rule on privately-held free stocks.

Using firm-level decision models, Meyers and Jolly (1980) developed some of the theoretical underpinnings of farmer demand for reserves. Viewed as an investment generating a temporal flow of storage costs and returns, the firm-level FOR marketing option is evaluated in their work

relative to a current cash sale option by means of stochastic efficiency criteria. The demand for farmer held reserves in the aggregate can then be derived from the firm-level decision, given current market conditions and FOR program provisions. Chambers and Foster (1983) note that farmers placing grain in the program are likely to be younger in age, operating farms producing primarily grain, with large on-farm storage facilities. Results of a farm survey conducted by Meyers, Jolly and Ryan (1981) reached essentially the same conclusions. Farmer participation in the program by region, has been summarized by Burnstein (1980) and Sharples (1982).

An evaluation of the FOR program cannot take place without consideration of the role of the FOR in the total policy package. As Womack et al. (1984) mention, the Farmer-Owned Reserve is part of the buffer stock-supply management program which forms the cornerstone of the 1977 and 1981 farm bills. The "balanced" use of the FOR and acreage adjustment programs is emphasized as an important prerequisite in the successful achievement of price and income objectives.

CHAPTER II. PRICE STABILITY AND THE FARMER-OWNED RESERVE IN THE

CONTEXT OF U.S. AGRICULTURAL POLICY

As background for an informed evaluation of the FOR program and its

merit as an instrument of agricultural policy, it is useful to be acquainted

with some of the issues and objectives of U.S. agricultural policy, as well

as the role of a managed buffer stock program, such as the FOR, in

stabilizing commodity markets. This chapter begins by briefly examining

some of the reasons for public intervention into agricultural markets, and a

few of the issues confronting agricultural policymakers. Following this is

a short recount of the changing farm problems of the last few decades, with

emphasis on the emergence of market instability as a chief concern in

commodity markets in recent times. The desirability of stable grain prices

is then probed, followed by a discussion of some of the operational

considerations that surface in the management of a nationally-implemented

grain reserve program.

Overview of U.S. Agricultural Policy

Throughout the years the government has maintained an active presence

in agricultural markets. From the depression days on, the basic philosophy

has remained that the government must intervene to adjust supply to maintain

prices that are politically acceptable, or failing to achieve an increase in

prices, to make payments to producers of certain farm crops to bring returns

to an acceptable level (Johnson, 1973). While agricultural policy

objectives have changed over time, the major farm programs today are much

the same as those devised and implemented over fifty years ago, as part of the Agricultural Adjustment Act of 1933.

Rationale of government intervention

The extent of government involvement in agricultural markets has and will continue to be a major item of controversy. The specific reasons for government intervention have changed as the nature of the farm problem and the overall political, social, and economic environment within which agriculture operates, has changed. Summarized below are several arguments put forth by Paarlberg (1980) for the existence of and continued intervention of the government into agricultural markets.

Of foremost importance is the argument that government involvement is a necessary step in partially alleviating the ongoing economic disadvantage of farming operations relative to other forms of business. Proponents of government action in commodity markets frequently quote historical trends in such statistics as net farm income, parity ratios, and the ratio of per capita income of farmers to the per capita income of nonfarmers, as evidence of the distressed situation in agriculture. The relative disadvantage of agriculture as a viable business, attested by these statistical series, is often cited as the prime reason for the existence of farm programs designed to raise farm prices and incomes.

Related somewhat to the first argument, a second justification for government involvement centers on the tendency of farmers to overproduce -- with a subsequent depression of agricultural prices. Such proneness has been attributed to several factors, including the market structure within which farmers operate, the high value placed on

technological development, the extreme inelasticity of the demand for food,
and the relative immobility of most agricultural resources.

Third, government involvement can be justified on the grounds of
improving agricultural stability. The biological nature of production,
together with the gyrations of the market, make farming one of the most
unstable enterprises in existence. Lacking an effective means to avoid the
production and price risks inherent in farming, farmers are subject to
unexpected and sometimes substantial income fluctuations.

Government intervention is further proposed as a means of increasing
the market power of farmers. Agriculture is the only remaining large sector
of the economy that is for the most part, competitive in the classical
sense. Yet the firms farmers buy from and sell to, frequently possess some
degree of market power or influence over prices. Frustrated, farmers as a
whole desire a degree of power sufficient to countervail the actions of
those encountered in the marketplace.

Lastly, Paarlberg notes that government farm programs thrived for some
time on the popularity received by the early programs of the 1930s.
Forestalling what might otherwise have been a political upheaval, the
commodity programs implemented in the depression days were highly
successful, and served as an argument for continued federal assistance for
decades.

Two additional arguments advanced by Gardner (1981b) include the
premise that government intervention is necessary to countervail the actions
taken by other governments, and as a response to the threat posed by large
scale, mechanized farming. To the above list might also be added the

assurance of an adequate food supply as major justification for government involvement.

Issues in agricultural policymaking

Pressures for public action arise when groups within the private sector dissatisfied with current conditions, are unable or perhaps unwilling to bring about the necessary changes through private means. Because agriculture affects us all, a broad array of interests is involved in the making of food and agricultural policy. The major groups affected are farmers, consumers, agribusinesses, and taxpayers. Society as a whole is also affected, to the extent that agricultural policy influences overall societal welfare.

A major obstacle in the policy formation process involves the establishment of a list of current priorities for the policy. Each of the above groups has its own interests and objectives for an agricultural policy not all of which can be met. The objectives which carry the most weight depend heavily on current economic conditions in addition to political philosophy.

The policy objectives held by members of the constituencies are largely static with respect to time, primarily because members of the same group share economic, social, and political goals. Farmers, among other things, are obviously concerned with earning reasonable rates of return on their resources, while consumers are primarily interested in the assurance of adequate supplies of low-priced food.

While not exhaustive, some of the specific farmer-held objectives for agricultural policy include:

1. A reasonable or fair economic outcome to farming operations.

2. A reasonable or fair stability in economic outcomes.

3. Open access to foreign markets with a minimum of impediments to trade imposed by other nations or the U.S. government.

4. Freedom in making production and marketing decisions.

5. Environmental protection, including conservation of land and water.

6. Compensation for burdens imposed on farmers by society that are unrewarded by the market (e.g., export embargoes, environmental regulations, food price controls).

7. Preservation of the family farm.

Considered together, the farm policy objectives of consumers, taxpayers, and society as a whole, include:

1. Adequate quantity, quality, and variety of food at reasonable or fair prices.

2. Reasonable stability in food prices consistent with sufficient price movement to efficiently allocate resources as dictated by shifting consumer demands.

3. Farm commodity export sales to earn foreign exchange and create favorable exchange rates.

4. Transfer payments to provide minimum adequate diets for those who lack resources to purchase such diets from earnings.

5. Low treasury cost.

6. Minimum administrative and bureaucratic requirements.

7. Equitable distribution of tax dollars.

8. Efficient resource use and product allocation in agriculture as well as the economy as a whole.

9. Equitable sharing of the benefits of economic progress.

10. Environmental protection.

Obvious conflicts exist in the above sets of objectives. These exist not only between the objectives of different groups, but also between the objectives held by the same group. For example, the farmer-held goal of price supports that bring returns on resources for large, efficient farms comparable to what those resources would earn in the nonfarm sector leaves small, inefficient farms with low average returns. On the other hand, establishing a support price that brings parity resource returns for small farmers creates windfall gains for large, efficient farms. The objective of freedom in making production and marketing decisions is additionally, inconsistent with farmers' desires to have the government intervene in agriculture.

The most prominent conflicts, however, exist between the goals of the different constituencies. As Tweeten (1979, p. 57) emphasizes, "the most sobering overall reality is that no food and agricultural policy simultaneously provides high farm income, low food cost, and low taxpayer cost." Which of these interests receives preferential treatment in the making of policy depends closely on current and expected economic conditions. As Hathaway (1981) points out, policymakers cannot always concern themselves with longer run objectives, since they are forced to deal with today's problems, and with groups which expect certain policy responses to be forthcoming. If farm and food prices are low, and expected to remain low, farm interests will be prominent in policy formulation, whereas if farm and food prices are expected to be high, nonfarms interests will likely be represented in legislation. While special interest groups provide the motivating force for the policy process and can be extremely effective in eliciting desired policy actions, final policy decisions are politically

based. Public policy according to Tweeten (1979, p. 42), thus tends to be "a compromise of the economically desirable, socially acceptable, and politically feasible".

Aside from formulating current objectives for agricultural policy, several additional problems are introduced into policy decisions. As Hathaway (1981) points out, the ability to adopt and maintain a policy depends not only on whether the objective itself appears reasonable, and with the desired outcome, but also on whether the proposed route to the policy objective is tenable. He argues that situations have occurred in the past where a particular policy objective was desirable, but the "means" by which the objective was to be attained, were not. In some circumstances, objections over the proposed means were so extreme that officials were forced to abandon the entire policy. Moreover, Hathaway adds that policymakers must recognize the fact that variables in the economic system beyond their control, may easily "swamp" the effect of the few economic varibles that they do control. The occurrence of this overpowering effect can lead to allegations that available policies were used ineffectively when in fact they weren't. Together with the short time allowed policymakers to reach decisions, Hathaway maintains that the above problems tend to result in a series of short run policies that appear to be unrelated to the administration's stated long run objectives.

Changing Farm Problems and Policy Concerns

From the 1930s through the 1960s, the most pervasive farm problem was low prices and income stemming from a chronic excess capacity to produce. During this period, farm income averaged only 51 percent of nonfarm income

and did not exceed 70 percent until 1965. The nature of the problem led to extensive government involvement in agriculture. Policy efforts were directed primarily towards price support, with production control via voluntary acreage reductions and some paid land diversion. Other programs such as PL480 were subsequently implemented to dispose of the massive government stocks accumulated under these programs in the fifties and sixties. Acreage reductions were in effect every year from 1961 to 1972.

However, commodity markets underwent a dramatic transformation in 1973. At a time in which the world was experiencing grain production shortfalls, factors such as a movement from fixed to flexible exchange rates, an increase in income levels in food deficient countries and a change in Soviet import policies combined to sharply increase the demand for U.S. grain exports. No longer was the U.S. characterized by surplus production. U.S. exports of feedgrains and wheat, for example, increased 88 percent from 1971 to 1973 as domestic grain stocks dropped to record lows. The increase in export demand drove up commodity prices, and net farm income which on a per capita basis, surpassed that of nonfarmers for the first time ever in 1973.

Subsequent gains in U.S. grain production, however, outpaced the growth in exports, and the high prices of the 1973-74 period, plummeted in the 1975 and 1976 crop years. Net farm income followed the price turnaround, as carryover stocks of grain increased to levels characteristic of the early sixties.

The sharp reversal in commodity markets sparked new concern as to the future directions of U.S. agriculture. The problem of chronic surpluses, so characteristic of earlier periods, had been replaced by a problem of periodic surpluses and deficits. Variability in prices, as measured by the

coefficient of variation, doubled for wheat, and more than tripled for corn

and soybeans from the sixties to the seventies. Price and supply

variability rather than low prices and income, thus emerged as the primary

farm problems of the mid-1970s. As such, pressure from both consumers and

producers came to bear on policymakers to refocus policy efforts towards the

stabilization of commodity markets, and the assurance of adequate food

supplies.

Instability and Buffer Stocks

The issue of market instability in the context of policy problems,

raises two questions. The first question is whether or not stable markets

are desirable from the societal point of view, and secondly, what role, if

any, should the government pursue in stabilizing markets. These issues are

each taken up in this section.

The desirability of stable commodity prices

The relative benefits of stable commodity prices can be evaluated by

considering either the overall welfare gains of stabilization, in terms of

producer and consumer surplus, or the implications of stable prices from the

perspective of economic efficiency.

The issue of welfare gains and losses to price stabilization is largely

a theoretical problem and research in this area has proliferated since the

early works of Waugh (1944) and Oi (1961). These types of studies primarily

rely on the economic surplus approach in measuring the welfare implications

of stable prices. Some (including Waugh and Oi) have postulated that

producers and consumers in certain circumstances benefit from unstable

prices. Others, such as Samuelson (1972), who was extremely critical of the

Waugh-Oi approaches, and Massell (1969), were among those to demonstrate net gains from stable prices in any situation. Where a specific type of government intervention was investigated, Konandreas and Schmitz (1978), assuming the existence of a costless buffer stock, found in their work that producers and consumers as a whole benefit from stable commodity prices. Helmberger and Weaver (1977), on the other hand, concluded that competitive storage with no government intervention maximizes welfare gains for producers and consumers.

Although the welfare literature is mixed, the weight of the evidence supports overall gains to price stabilization and stabilization schemes. However, the issue of who gains and who loses to such schemes is crucially dependent on the assumptions used, such as the form of the disturbance term, the type of risk response, and assumed demand and supply specifications. As Just et al. (1977) point out, even a switch from linearity of the functions to log linearity can be sufficient to reverse who gains and loses from price stabilization.

Perhaps a less controversial case for stability can be made by considering the implications of stable prices from the perspective of economic efficiency. Economic efficiency is hindered by unforeseen random events which create loss of value of goods and services produced and consumed. Trends, cycles, and other variation in the economic system which can be anticipated and adjusted to with a high degree of precision, are not uncertainties, and hence, not a source of economic inefficiency.

Gains in economic efficiency accrue primarily in the areas of allocative and operational efficiency. Allocative efficiency is enhanced when changes in prices induce resources to move to higher value uses. Some

variability in prices is therefore, necessary to efficiently allocate resources and products in response to changes in the economic system, but as Tweeten (1979) notes, far more variability exists in the economy than is necessary. Operational (or productive) efficiency, on the other hand, is improved when resources are more effectively utilized in the production process.

From the standpoint of allocative efficiency, unstable prices compound the resource allocation problems already present in agriculture, and attributed to the relative immobility of most agricultural resources, as well as the biological lags present in agricultural production. Such an inefficiency arises, for example, when a favorable cost-price relationship for a particular crop at planting time completely reverses by harvest. Resources transferred away from other enterprises and committed to production of the crop were misallocated to the extent that they were routed to lower, rather than higher value uses. In such a situation, stable prices would be expected to alleviate potential cash flow problems which would occur when prices declined following a period of net investment.

A more important inefficiency growing out of economic uncertainty, however, is inefficiency in farm production, or operational inefficiency (Heady, 1952, p. 740). To reduce the business and financial risks of farming, strategies including diversification of enterprises, flexibility in changing operations, and liquidity are frequently adopted by farmers. However, the application of these strategies results in a reduction of output per unit of input. For example, while diversification of farm enterprises can be shown to substantially reduce overall production risk, especially if there exists a negative correlation between returns to

diversified enterprises, it also sacrifices some net farm income for the reduction in risk, and results in forfeited gains to specialized production. By the same reasoning, flexibility in changing enterprises from year to year often requires a farmer to forego large investments in specialized, efficient machinery which similarly results in a loss of operational efficiency. Moreover, liquidity, as a financial risk-reduction tool, decreases operational efficiency in that to maintain a degree of liquidity sufficient to meet financial obligations, farmers may hold excessive cash reserves which could be invested in productive and profitable inputs.

A final source of inefficiency at the farm level centers on the distributional impacts of market variabilities on farms with different financial structures. Farmers most susceptible to unexpected price fluctuations include beginning operators, full-time farmers who are heavily indebted, and owner-operators of expanding, full-time medium-sized farms. Individuals in these situations are often efficient producers, but because of their precarious financial situations, are the least capable of coping with the business and financial risks inherent in farming operations. Ordinarily, unfavorable economic conditions in an unstable economy are expected to weed out inefficient producers, but to the extent that these uncertainties causes a preponderance of farm liquidations among the efficient, but overleveraged farmers, rather than the less efficient, established farmers, it represents a source of inefficiency.

Reutlinger (1976) points out that there may also be macroeconomic attributes of stable food prices in that stable prices help to stabilize the effective incomes of low income individuals. Moreover, Burnstein (1980) notes that while high commodity prices drive up retail food prices, a

falling off of commodity prices fails to lower food prices. Hence, stable farm level prices could help to alleviate what he terms, a "ratchet" effect on food prices. A decrease in the variability of food prices is also credited with increasing the demand for food relative to other nonfood commodities (Tweeten, 1979).

The role of a buffer stock

Variations in prices can be diminished by increasing the elasticity of demand and/or supply. As Johnson (1975, p. 824) indicates, these relationships can be made very elastic for a given geographical area by either managing the flow of trade, or managing storage. Historically, for food and feed grains, the approach which has received the most attention in the United States is the management of storage via buffer stocks.

The question of buffer stocks of grain for the U.S. is not new, but was considered by economists along with other stabilization instruments over thirty years ago. However, the issue took on new meaning in light of the commodity market events of the mid-seventies. As Brandow (1976, p. 92) pointed out at the time, "a reserve stock policy for grains in the U.S., as a means of stabilizing markets and of facilitating food aid, has emerged as a national issue, free for the time being, of domination by price and income support objectives." Maintaining that grain stocks carried by the commercial trade are too small and inadequate to meet the nation's objectives, Brandow advanced several arguments for the establishment of a nationally implemented grain reserve. These include the arguments that a national grain reserve would:

1. Help curb the instability arising from export demand
   variability which conventional market mechanisms are
   incapable of controlling.

2. Encourage the long range development of commercial grain
   exports through dependable U.S. supplies and stable prices.

3. Allow the U.S. to become a more stable source of foreign food aid.

4. Increase the stability of output and prices in the
   livestock industries.

5. Enhance food price stability for macroeconomic reasons.

6. Decrease the uncertainty and hence, increase the efficiency
   of grain production.

7. Increase the utility of risk-averse producers.

Specifically, government intervention into the speculative grain

stockholding activity of the private sector is aimed at maximizing social

benefits rather than private benefits to grainholders. Since the free

market is assumed to fail in maximizing social benefits, the primary

argument for a public storage program lies in the premise that it is more

effective than the free market in attaining the desired level of stocks and

price variation.

Basic mechanics of buffer stock operation

Operationally, a buffer stock program is designed to partially

stabilize prices. The major emphasis of such a program is on increasing the

probability that market prices will fall within a pre-established price

band. Since fluctuating prices are necessary to allocate production and

guide the product through the channels of trade, from a social standpoint

then, as well as operationally, a complete stabilization of prices is

infeasible.

The price band is defended through accumulation of stocks at prices

below the band, and release of stocks to the market at prices above the band. The acquisition price, which specifies the price at which stocks are acquired, defines the lower end of the price band. The release price, or trigger level, specifies the price at which stocks are returned to the market and defines the upper end of the band. If successful, the program should cut-off or at least moderate peaks above the release price and troughs below the acquisition price in the price pattern over time.

The operations of a buffer stock program can be illustrated quite simply (Figure 2.1). The price band is normally set so that it encompasses price in a "normal" year. In "short" crop years, the free market price would lie above the band, whereas a bumper crop would likely depress prices to levels below the band.
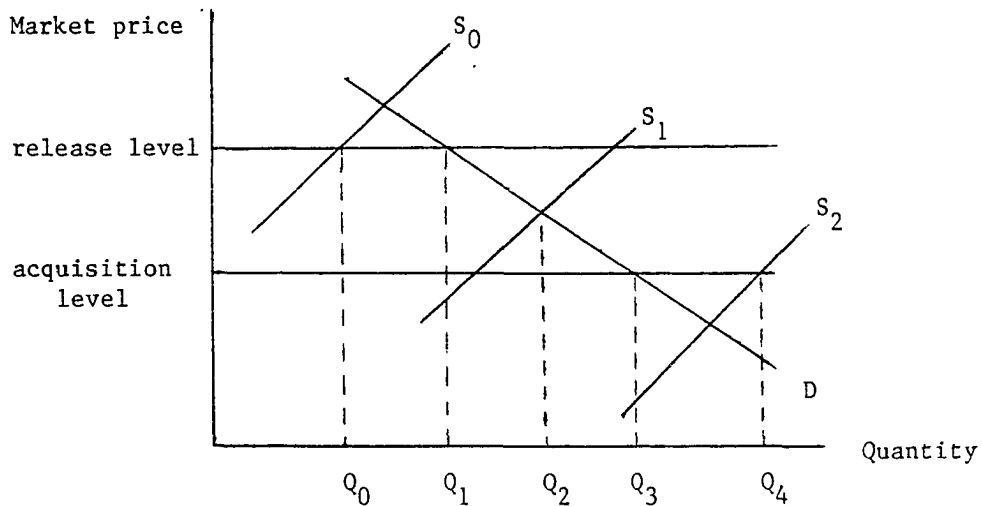

Figure 2.1. Buffer stock operations under alternative supply situations

In normal crop years with no stock program, the equilibrium quantity traded in the market would equal Q_2 and price would be maintained within the

price band. To push market price into the price band in periods of large

supply S_2, incentives to place grain in the program must be large enough to

remove the quantity Q_4-Q_3 from total supply. This amount would enter the

program and the quantity marketed in normal outlets would equal Q_3. In a

short crop period with supply at S_0, stocks of grain in the program would be

triggered. The quantity Q_1-Q_0 would need to come out of the program in

order to enforce the top of the band and drive market prices down to the

release level. Under this situation, the market would clear the quantity Q_1

at the release price.

In this manner, a buffer stock defends the pre-established price band.

Low prices trigger incentives to place grain in the program while high-side

prices stimulate action to bring these stocks back on the market. However,

the successfulness of the program in attaining its objectives depends on a

couple of key factors. To defend the top of the band requires a sufficient

quantity of grain in the buffer stock at the start of the period. If total

program stocks were less than the quantity Q_1-Q_0, prices could not be driven

down to the release level. On the other hand, the ability to defend a price

floor at or around the acquisition price depends on adequate producer

participation, and nonconstraining or no ceiling levels on total program

stocks.

Operational Considerations in Grain Reserve Management

A grain reserve may be operated as either a buffer stock, a price

support mechanism, or some combination of the two. In this section,

attention is focused on a few of the operational issues that surface in the

management of a grain reserve solely as a buffer stock.

Many complexities are involved in the management of a national grain reserve program. Operationally, when establishing the price settings and rules for reserve accumulation and release, the managers of the program must attempt to address the diverse interests of each of the major groups involved. Excessive concessions to one group at the expense of another will obviously bring about dissatisfaction with the program as well as move the price to the boundaries of the price band. Consumers, processors and livestock producers have an understandable desire to see that grain prices remain relatively low and stable. Grain producers on the other hand, profit from high grain prices and in spite of the benefits of price stability there is some evidence that grain producers may to a degree, benefit from price instability (Johnson, 1976, p.169). Moreover, as the federal budget grows tighter, due consideration must be given to the program's costs.

Of primary importance to program managers is the specification of the loan rate (i.e., acquisition price) and release price which comprise the price band. Since the desired degree of price stabilization is implicit in the price band setting, consideration must be given to several factors. The position, as well as the width of the price band have noteworthy implications.

A major item of importance is the position or bounds of the price band relative to the expected price in a "normal" crop year, as well as to producers' average cost of production. A price band established so as to encompass both of these variables encourages efficient production and tends not to exert an undue influence on price trends through time. In addition, all else equal, it will maintain the relative profitability of competing crops so as not to impede the market's role in the allocation of resources.

A price band too high may have several adverse outcomes. For one, it tends to promote excessive profits in the production of program crops. As Knutson et al. (1983, p. 256) emphasize, profits in agriculture are quickly translated into inflated land prices and expanded debt service costs. Large profits also tend to shelter inefficient producers and decrease incentives to cut production costs. By the same reasoning, it encourages overproduction and develops a tendency among farmers to produce for the artificially high prices of the program. This action ties up stocks in the program and "shorts" the market.

Prices supported too high also imply trade market consequences. Since loan rates in the U.S. exert a heavy influence on world prices, high loan rates tend to protect our foreign competitors and encourage stepped up production efforts on their part, increasing the competition for agricultural exports. Foreign countries operating under a price umbrella created by high U.S. loan rates are able to undercut U.S. prices, capturing larger shares of the export market. The U.S. position in this situation is relegated to that of a residual supplier in the export market, providing only the portion of overseas sales that our competitors cannot.

On the other hand, a price band established too low relative to the expected price and the average cost of production would depress profits and encourage the transfer of farm resources to other commodities. Large reserve stocks would be necessary to defend such a price band since a continual release of these stocks would be required to moderate upward price pressure. The effect of low support prices is also to subsidize grain use instead of reducing marginal consumption.

A further consideration arises with respect to the positions of price bands among related program crops. As Womack et al. (1984) point out, the price bands must reflect, and permit, intermarket linkages for both supply and demand. Their relative positions should also be such that they maintain the proper relationship in terms of feeding importance.

The width of the price band, and subsequent degree of price protection involved are particularly important, but often slippery issues. Price changes should signal needed adjustments in production and consumption. In order to do so, however, prices must be permitted to move over a sufficient range to attract resources and discourage consumption in years of tight supplies while discouraging production and encouraging grain use in years of plenty.

A narrow price band constrains the market and is difficult to enforce especially if supply and/or demand is relatively inelastic. The narrow price band necessitates a large buffer stock due to the increased probability that market prices will violate the price band. This translates into increased program costs in the form of expanded outlays to acquire these stocks and carry them forward from year to year. A narrow price band also reduces the freedom of market forces in guiding consumption and production decisions.

Too wide a price band, on the other hand, does little to stabilize prices. While the program costs, and the size of the stocks needed to meet most supply imbalances are smaller, price uncertainty is increased. As argued earlier, the effect of economic uncertainty is to induce the farmer to adopt a more diversified, or more flexible farm plan than he would otherwise. This may imply a high price to pay in that the farming system is

less efficient, and less profitable, than a more specialized inflexible system. A wide price band, however, would exert greater pressure on other countries to assume a larger share of the burdens of maintaining grain stocks while simultaneously encouraging larger privately held speculative stocks at home.

For the major feedgrains, the price corridors cannot be specified without regard for their impacts on livestock markets. Given the importance of corn in livestock feeding, its price band must be such that it imparts an acceptable amount of instability on the livestock industry. Livestock and poultry enterprises are essentially margin operations. Economic efficiency is promoted by margin stability, in that instability tends to break the overexpanded and financially vulnerable producers who are frequently not inefficient producers (Breimyer and Rhodes, 1975).

While there are many considerations and compromises involved in establishing the rules of the program, one of the most important requirements is that the rules be effectively communicated so that market participants have clear signals for production and consumption decisions. The government by implementing such a program is substituting its own decision-making for the uncertainty of the market. Yet, as Paarlberg (1980) reminds, government decision-making itself is an uncertainty, and more importantly, may be wrong. The primary justification for a buffer stock or reserve program is that it is more effective than the free market in maximizing societal welfare. As such, the program managers must be careful in avoiding erratic provision changes that may force more uncertainty and instability on the market than would prevail in the absence of such programs.

CHAPTER III.   DESCRIPTION AND OPERATIONS OF THE FARMER-OWNED

CORN RESERVE PROGRAM

Presented in this chapter is an overview of the provisions and

operations of the Farmer-Owned Reserve program for corn. The first section

entails a description of the program as enacted by Congress in 1977. It

includes a summary of the program provisions which govern FOR stock activity

and the extension of FOR loans. The second section highlights market

developments and FOR operations for the years 1977-1983.

Description of the Farmer-Owned Reserve Program as Mandated
by the Food and Agriculture Act of 1977

The Food and Agriculture Act of 1977 mandated a farmer-held wheat

reserve, and authorized a farmer-held feed grain reserve. Both are

voluntary commodity programs and have been in operation since 1977.

The eligible farm producer may participate in the FOR program by

entering into a contract with the Commodity Credit Corporation (CCC). Under

the terms of the agreement, the farmer may place any amount of his current

crop in the reserve program with the stipulation that it remain there for a

period of three years. Ownership of reserve grain, as implied by the title

of the program, is not transferred to the CCC but remains with the farmer,

who is subsequently responsible for the maintainence of its quality.

With the grain as collateral, the farmer is eligible to receive a loan

from the CCC for the term the grain is held in the reserve. The loan amount

is equal to the program loan rate per bushel times the number of bushels

placed in the program. The interest charged on the loan is a subsidized

rate set by the CCC. Currently interest accrues for the first year of the loan only. The interest period in the past has varied from three years, when the program was initiated, to a period in 1981 when the interest charge was waived entirely.

As an added incentive for participation, the program offers advance annual storage payments, currently equal to 26.5¢/bushel/year. This payment may be used by the farmer to compensate for the on or off farm cash storage costs of holding reserve grain. The first payment is received at the time the contract is signed. Additional payments follow on the first two anniversaries of the contract.

Participants are only required to keep their grain in the program for the three year duration if prices do not rise above a prespecified release price. If the average mid-month farm price equals or exceeds the release price (currently 112% of the loan rate for corn), the reserve moves into "release status" and reserve stocks are triggered. Release status has a minimum duration of the month in which the release price is exceeded plus the next month. During this period, the farmer is allowed to repay the loan prior to its maturity and market the grain taking advantage of the higher price. As a redemption incentive, storage payments may be suspended after the second consecutive month in release and the interest charge on the loan reimposed at current CCC rates.

Loan redemption becomes mandatory if the market price advances from the release price to the call price. In this event, participating farmers must redeem all FOR loans within a ninety day period. Failure to repay the loan within that period results in forfeiture of reserve grain to the CCC. No grain placements are allowed when the reserve is in call status.

If by the end of the three year term, the market price never reached the release level, or the farmer did not choose to exercise the redemption option in release status, two alternatives exist in fulfilling the terms of the contract. The farmer may repay the loan plus accrued interest and keep the grain regardless of the price or he may utilize the nonrecourse feature of the loan. The nonrecourse option allows the farmer to default on the loan in which case the reserve grain is forfeited to the CCC as full loan payment.

Participation in the FOR is limited to only those farmers in compliance with the current year's set-aside program, if one was in existence. For crop years in which no set-aside program was in effect, all producers of the eligible crops are allowed to participate provided they certify their planted acreages with the government. When the program was first initiated, there was the added participation restriction that required producers to first obtain a CCC price support loan and sit out the nine month term before placing in the FOR program. That restriction, however, was later waived by the Secretary of Agriculture and direct entry into the program has been allowed ever since.

While there are many additional features of the program, only a few are noteworthy in this study. The Secretary of Agriculture is first authorized to impose ceilings on reserve quantities. The minimum ceilings currently allowable are 700 million bushels for wheat and 1000 million bushels for feed grains. Furthermore, when the FOR program is in existence, the CCC may not sell any of its stocks of grain at less than 105 percent of the call price for each commodity, thereby permitting a maximum reliance on the FOR before invoking the release of government held stocks. And finally, a new

reserve contract is written up whenever there is a major change in program

provisions. Thus, at any point in time, there may be multiple contracts

outstanding, each with different loan and release prices, etc. These

contracts have been labeled Reserve I, II, III, etc and are listed below

with the effective grain placement dates under each:

Reserve I   program inception - January 7, 1980
Reserve II   January 8, 1980 - August 24, 1980
Reserve III   July 28, 1980 - October 5, 1981
Reserve IV   October 6, 1981 - June 30, 1982
Reserve V   July 1, 1982 - present.

Several revisions to the program were enacted under the Agriculture and

Food Act of 1981. Operationally, the most significant of these was the

termination of the call price and mandatory redemption. Correspondingly,

the minimum resale price of CCC-owned stocks was adjusted from 105 percent

of the call price to 110 percent of the release price per commodity.

The 1977 and 1981 Acts grant the Secretary of Agriculture a large

amount of flexibility in determining the program's provisions. Once the

national loan rate is established, the Secretary has considerable latitude

in setting the release and call prices. For corn, there are no bounds on

the position of the release price relative to the loan rate. For wheat, the

release must be no less than 140 percent and no more than 160 percent of the

loan rate. The Secretary can in addition, manipulate the other provisions

of the program if market conditions warrant. For example, he can change the

participation rules, interest rate and period, and storage subsidy to

influence placements. To influence redemptions, he has the authority to

change the interest charge on loans in release status, call loans before

maturity, and extend the loan term to five years. As a result, the

provisions of the program have become quite sensitive to current and

expected market developments, with the frequency of such revisions being thought to introduce unnecessary uncertainty into commodity markets (Just, 1981, p. iii). A chronological review of the provisions for the corn reserve is contained in Appendix A.

Operations of the Farmer-Owned Corn Reserve, 1977-1983

The FOR program does not limit the amount of grain an individual farmer may market, but it does affect the timing of grain marketings. The program offers farmers a temporary alternative to direct sale or speculative storage. As such, the quantity of grain that enters the reserve is expected to be quite responsive to current market prices and outlooks.

Presented in this section is a brief recount of FOR operations and market developments for the first six crop years of the program. Little effort is made in disentangling the price influences of the program from that of other market events. Rather, the objective is to provide a descriptive summary of events during this period for the purpose of examining the response of the program's provisions, and farmer participation to current market conditions.

1977/1978

The 1977/78 crop year for corn was characterized by record production and exports. The increase in production over the previous year resulted primarily from improved yields while most of the increase in the demand for exports was attributed to renewed purchasing by the USSR which was itself experiencing severe crop shortages. Despite strong exports prices remained low, averaging around $2.05/bushel. Hog/corn and steer/corn price ratios,

on the other hand, surged to their highest levels since 1972, resulting in record numbers of livestock on feed.

In spite of relatively low prices, farmers appeared to be exercising restraint in placing corn in the FOR. For much of the year, market prices remained close to the loan level (Figure 3.1), and did not fall to more than five cents below it. The placements that did occur took place in the latter months (Figure 3.2), reflecting the restriction that 1977 crop grain placed in the FOR must first pass through the nine month regular CCC loan program. Largest monthly placements were 72 million bushels, and ending FOR stocks stood at 235 million bushels.

1978/1979

Another record corn crop followed in 1978. In spite of strong set aside incentives, production shot up 12 percent from the previous year, pushing prices below the loan level. Concerned that reserve target quantities would not be met, program managers dropped the nine month restriction and allowed "direct entry" of the 1978 crop into the FOR. Although less than half of all farmers participated in the set-aside, and were thus eligible to place grain in the FOR (Table 3.1), reserve stocks rose dramatically from October to December and direct entry was discontinued. In the first four months of the crop year, FOR stocks more than tripled to 714 million bushels.

Continued strength in the demand for feed and a surge in exports brought about a mid-year price turnaround. Expanding livestock numbers and a hard winter combined to lift total feed disappearance to over 4.3 billion bushels for the year -- the third largest on record. The sub-two dollar
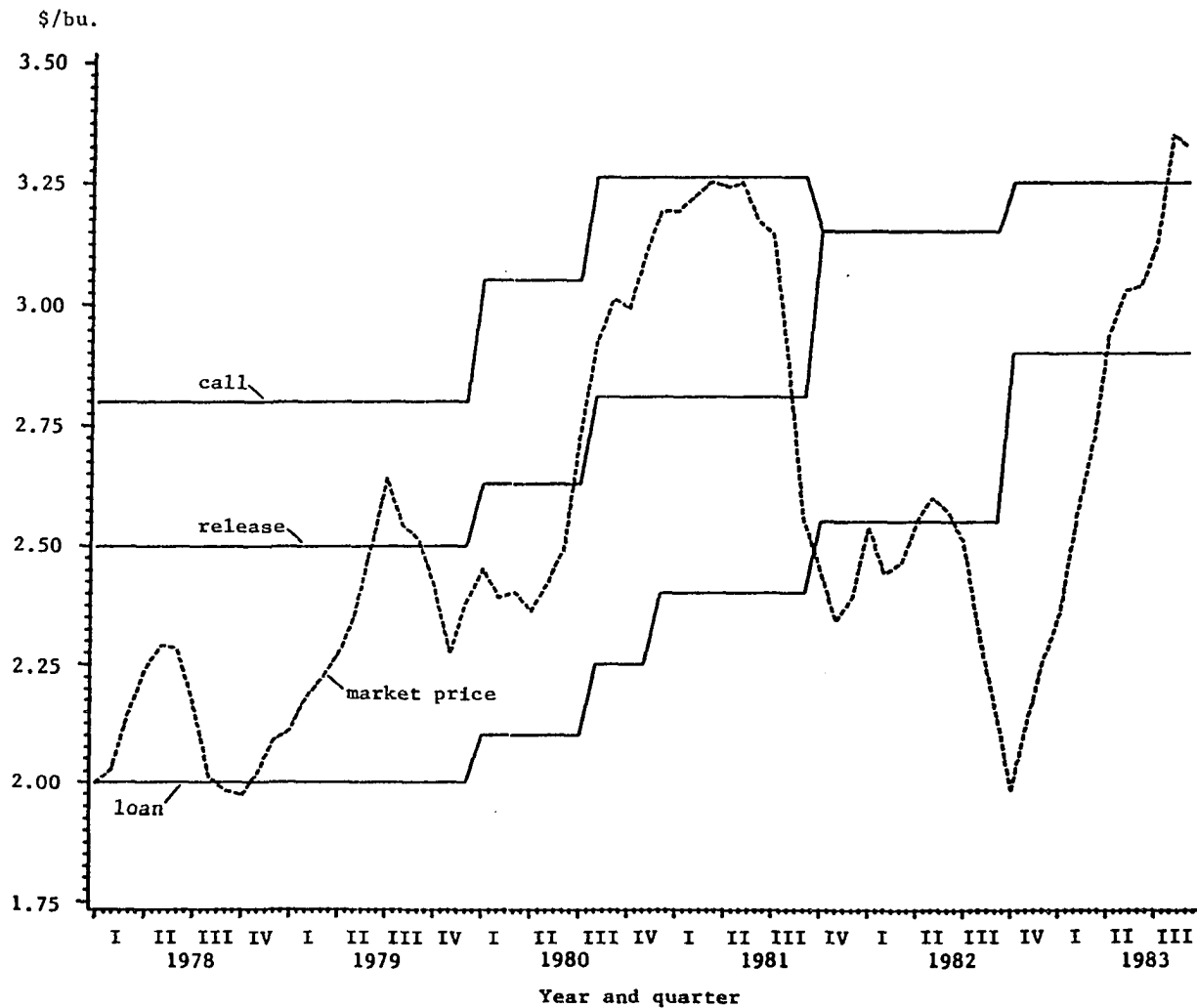
$/bu.

Figure 3.1. Market price of corn in relation to Farmer-Owned Reserve loan, release, and call levels

Year and quarter

42

Mil. bu.
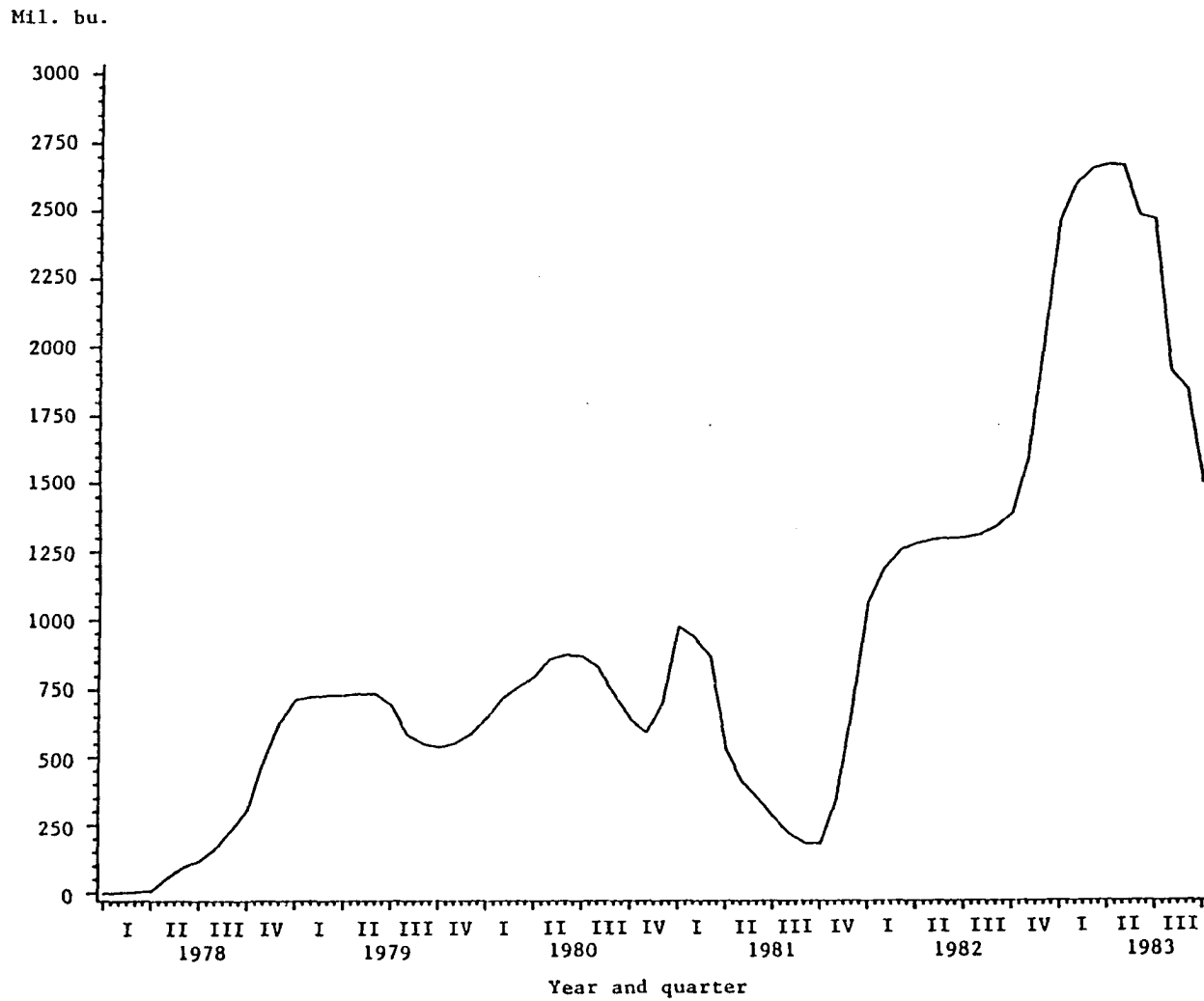
Figure 3.2. Total quantities of corn in the Farmer-Owned Reserve

Table 3.1 Proportion of corn producers eligible for participation in the
Farmer-Owned Reserve program, 1977/78 - 1982/83.

Crop year	Percent of corn producers eligible for participation
1977/78	100
1978/79	41
1979/80	21[a]
1980/81	100
1981/82	100
1982/83	23

[a] In response to the Soviet grain embargo, the participation restriction
on the 1979 crop was waived from April 15, 1980 to June 13, 1980.

harvest prices recovered through the year to over $2.60, prompting release

of reserve stocks in June. The reserve remained in release for almost three

months, moving about one-third of total reserve stocks back on the market.

1979/1980

The 1979/80 year was characterized not only by another record in corn

production, but also by uncertainty in grain markets rising out of the

Soviet grain embargo. Low participation in the acreage program, and average

yields near 110 bushels/acre combined to stimulate production to almost

eight billion bushels. Prices in the first three months of the crop year,

however, remained strong at around $2.40/bushel supported mostly by

continued strength in the demand for livestock feeds. Pork and broiler

productions for example, were up 21 percent and 6 percent from the previous

year, respectively, despite slipping feed margins. Placements of corn into

the FOR program were small in the first three months even though direct

entry into the program was again allowed for the new crop and old crop under loan.

In January of 1980, grain markets were disrupted by the administration's suspension of grain sales to the USSR. To counteract the market impact of the embargo the managers of the FOR programs made several provision changes designed to increase participation in the reserve programs. For corn, the loan level was raised to $2.10/bushel, with the reserve and call levels revised upward accordingly. Storage payments were similarly increased, and the interest charge on FOR loans (which had applied to only the first year) for a short period was waived entirely. Disappointed with farmer response to the enhanced benefits, the authorities in April allowed nonparticipants as well to place corn in the program. In total, however, the more attractive program features, and relaxation of the eligibility restriction contributed only modestly to corn placements. FOR stocks increased from 645 million bushels in January to a maximum of 872 million bushels in June. Strong export demand from other trading partners was to a larger extent responsible for offsetting the price depressing effects of the embargo.

Drought-influenced new crop prospects caused a tightening of late season markets with prices reaching the trigger level for the second time in July. That same month, the program parameters were again revised upward, implying little interest on the part of program managers in moderating the advancing prices. Loan levels were increased to $2.25/bushel, and the release and call levels to $2.81/bushel and $3.26/bushel, respectively.

1980/1981

Owing to a short production of 6.6 billion bushels, total corn supply for the 1980/81 year was down, despite large carryin stocks. Although exports were trending downward, feed demand remained particularly strong in the first half of the year, aiding in the support of prices above the release level for the period.

In December, the loan level was raised to $2.40/bushel, and the interest charge on FOR loans was waived. The release and call levels remained unchanged. With such revisions, the returns to program participation were so attractive that farmers were putting more corn into the program than they were taking out. Despite an already tight market and prices in the $3.15 range, an additional 470 million bushels entered the reserve. The increased demand for FOR stocks aided in driving prices to the call level in January for the first and only time throughout the FOR program.

Corn prices peaked at around $3.25/bushel early in 1981. Feed demand which had been strong in the early months was beginning to taper off in response to poor livestock/feed price ratios. Corn exports were also slipping as a result of several factors including a strong U.S. dollar, a world economic slow down, and increased production in major exporting countries. Argentina for example, was significantly expanding corn exports as a result of a two-fold production increase over the previous year. Although prices were falling, they remained above the release level through the summer. In July, the interest waiver on FOR loans was repealed. Total reserve quantities ended the year at 188 million bushels after peaking at 900 million bushels in February.

1981/1982

Because of the short 1980 crop, and forecasted decline in beginning
stocks for 1981, no set-aside was imposed on the 1981 crop. Good growing
conditions and large planted acreage contributed to a record corn production
of 8.2 billion bushels. In a two month period (August, 1981 to October,
1981), the market price dropped from above the release level to below the
loan level. To ease the transition from the short year to the new harvest,
loan rates were raised to $2.55/bushel. Similarly, the release level was
revised to $3.15/bushel, as the call level was terminated in accordance with
the provisions of the Agricultural and Food Act of 1981. The higher loan
and low market prices combined to induce the placement of over 1 billion
bushels of corn in the program from October to February. Yet with even 1.3
billion bushels locked up in reserve stocks, and a harsh winter increase in
feed demand, prices remained well below the loan level. The depressed
prices were largely attributable to the demand for corn exports which
started the year briefly strong then fell off sharply as the dollar
strengthened further, the European community increased its import levies on
feedgrains, and foreign exchange problems reduced the imports of many middle
and low income countries. The U.S. share of the world coarse grain trade
during this period fell to 59 percent from around 70 percent the previous
two years.

Following a momentary spurt in spring prices, prospects for an even
larger crop in 1982 dropped the bottom out of late summer prices.
Compounding this was the heavy pre-harvest marketing of FOR grain under the
"rotation" provision, whereby farmers were allowed to market old FOR grain

if replaced by new-crop grain. In July, the rotation period was extended from 30 to 60 days before harvest.

1982/1983

Markets entered the 1982 crop year under very weak conditions, which tightened substantially as a result of several second half developments. Record corn yields of 115 bushels/acre more than offset the three percent reduction in planted area resulting from the acreage program, and boosted total production to 8.4 billion bushels. Although feed disappearance was taking place at a rapid rate, fall prices fell to below $2.00/bushel. To encourage participation in the 1982/83 acreage programs, loan levels for the new crop were raised to $2.90/bushel. The more than ninety cent difference between the loan rate and current cash prices spurred another quantum jump in FOR placements. Although only 23 percent of all farmers were eligible, FOR stocks of corn climbed from 1.4 million bushels at harvest to 2.6 billion bushels in January. With massive stocks looming overhead and uncertain market outlooks, the administration on January 11 announced an experimental payment-in-kind (PIK) program, designed to substantially reduce planted acreage for the 1983 crop by substituting existing stocks for new crop production.

At the time of the PIK announcement, markets were already beginning to tighten. Rapid disappearance in the first half of the year at low prices had significantly drawn down free stocks, and prices were rising steadily to ration remaining stocks. Corn prices were also supported in the second half by strong demand for food, seed and industrial uses, which for the first time was advancing toward the annual mark of one billion bushels.

Late season prices responding to reduced plantings and drought-influenced production outlooks reached the release level in July, triggering reserve stocks. In September, to encourage farmers to liquidate their FOR contracts and market reserve grain, storage payments were suspended, and interest recharged on outstanding loans.

Reserve operations in summary

Several general observations stand out from the preceding discussion. An examination of corn prices over the period relative to the price rules of the program, indicates that the FOR was of limited effectiveness in maintaining the market price of corn above the loan level. Although for most of the program's first four years, prices remained above the loan level, price patterns in 1981 and 1982 cast serious doubt on the ability of the program to consistently enforce a price floor at or around the loan level. With the exception of May 1982, corn prices remained below the loan rate for eighteen consecutive months, despite the isolation of such large reserve quantities of corn from the market. The enhanced program provisions, which encouraged participation in the program and to some extent reduced the downward price pressure during this period, also caused the program to become extremely imbalanced. Substantial disparities were created between returns to program participation and returns in the marketplace during the 1981/82 and 1982/83 years. As a result, reserve stocks swelled to enormous levels, greatly increasing the costs of the program and necessitating drastic steps as were taken with the adoption of the PIK program.

The fact that corn prices remained below the call level for virtually the entire period appears to be more the result of depressed markets and high call levels than FOR operations. Judging from the chronology of FOR provisional changes, program authorities apparently placed little emphasis on suppressing upward price movements and enforcing the topside of the price range. Especially since the 1981 legislation, when the call level and mandatory redemption was terminated, the objective of the FOR has seemingly shifted towards protection only against low prices. This is also evidenced by the increase in loan rates that occurred during a release period in July 1980, and the interest waiver later that year when prices were already approaching the call level at $3.25/bushel.

The market impacts of the program, however, must be evaluated in light of the quite erratic market developments during the 1977-1983 period. By the very nature of removing grain from the market at low prices and providing grain to the market at high prices, the FOR promoted stable markets, but it appears this stability was overshadowed by instability in other market factors. The program's isolation of over 1 billion bushels of corn in 1982 and over 2.7 billion bushels in 1983, while not supporting prices above the loan level, undoubtedly exerted more influence on markets than would have taken place in the absence of such a program.

CHAPTER IV. THEORETICAL IMPACT OF THE FARMER-OWNED

RESERVE PROGRAM ON COMMODITY PRICE VARIABILITY

A simple market model is developed in this chapter for the purpose of examining from a theoretical standpoint, the ability of the FOR in moderating unexpected price shocks. In a comparative statics framework, reduced form multipliers are derived which are used to investigate the equilibrium price impacts of systematic demand and supply side shocks. The reduced form equations are further used to reveal those factors which directly affect the price stabilizing performance of the program.

Simple Model of an FOR Influenced Commodity Market

Conceptualized in this section is a simple model depicting the market structure for a single commodity in the presence of an operational reserve program. The model contains no intermarket linkages and is assumed linear in form with the stochastic terms suppressed. Although the emphasis in this study in on seasonal variation, for simplicity the model below is specified in annual terms. This approach essentially leaves the argument unchanged and greatly simplifies the specification.

For the purposes here, the model is composed of six equations which include four behavioral relationships, an expectations equation, and a market clearing identity. The model contains only endogenous variables, lagged endogenous variables, a demand shock variable (Z_t), and a supply shock variable (X_t). It abstracts from all other exogenous shifters.

The model is conceptualized as follows:

$$D_t = f_1(P_t, Z_t) \tag{4.1}$$

$$I_t = f_2(P^e_{t+1} - P_t, R_t, X_t + I_{t-1}) \tag{4.2}$$

$$P^e_{t+1} = f_3(X_{t+1} + I_t, R_t) \tag{4.3}$$

$$R_t = R_{t-1} + f_4(P_t, X_t, R_{t-1}) \tag{4.4}$$

$$X_{t+1} = f_5(P^e_{t+1}) \tag{4.5}$$

$$X_t = D_t + I_t + R_t - I_{t-1} - R_{t-1} \tag{4.6}$$

where:

D = demand for current consumption

P = price of the commodity

I = ending free stocks

P^e_{t+1} = expected price next year

R = ending reserve stocks

X = production of the commodity

Z = demand shifter

Equation (4.1) represents the demand for current consumption. The specification is kept simple since inclusion of this equation is not critical to the model's purpose, other than as a price responsive component of total demand. Demand for current consumption is postulated as a downward sloping function of current price, and an upward sloping function of the shift variable.

Equations (4.2) and (4.3) of the model were specified with the objective of incorporating into the model the crucial interactions that

exist between farmer-held reserve stocks of grain and privately held free

stocks of grain. Aside from the FOR's importance as a temporary marketing

substitute, the primary market impact of the program is on the demand for

privately held free stocks. The extent of this interaction carries with it

important implications for the price stabilizing potential of the FOR

program.

Sharples and Holland (1981), for example, have demonstrated that a

strong, inverse relationship exists between reserve stocks and free stocks.

Meyers and Ryan (1981) attribute this relationship to two factors. The

first factor, termed the substitution effect, represents the farm-level

substitution of reserve stocks of grain for privately held free stocks. In

other words, a farmer placing grain in the program would probably do so by

drawing down his current uncommitted or free inventories, thereby

substituting reserves for free stocks. This is essentially a one-way

substitution effect since released reserves are normally marketed in order

to satisfy the loan repayment obligation. The second factor, the

expectations effect, hinges on the presumption that large reserve stocks

once released, will be quite effective in suppressing continued upward price

movements. When reserve stocks build, therefore, the expected gains from

speculative storage, and hence, the demand for speculative stocks, decreases.

An objective in the model specification was to separate the above two

types of interaction so as to permit a separate examination of each. The

specifications of equations (4.2) and (4.3) were motivated with this in

mind. Equation (4.2) represents a supply of storage relation and

incorporates the substitution effect of reserves on free stocks. Equation

(4.3) allows for the expectations effect of reserve stocks, and can be

interpreted loosely as a demand for storage as derived by Brennan
(1958, p. 52)[1].

Ending free stocks of grain in equation (4.2) are assumed to be a
positive function of the price of storage $P^e_{t+1} - P_t$, a negative function of
reserve quantities, and a positive function of beginning free supply which
is the sum of current production and carryin stocks. The first term
represents the holding of stocks for speculative purposes, whereas the
second term reflects the substitution effect of reserves for free stocks.
The last term represents the storage rule, the slope of which determines the
marginal rate of stockpiling.

Equation (4.3) expresses a relationship for the market's expectation of
next year's price. The specification in part stems from the market clearing
identity for year t+1. The expected price is assumed to be negatively
related to the "observables" influencing next year's price. These include
ending free and reserve stocks, and next year's production, which together
constitute the supply of grain for the ensuing year.

Equation (4.4) describes the demand for farmer-owned reserves. The
equation is derived from the following identity:

$$R_t = R_{t-1} + QP_t - QR_t \qquad\qquad (4.7)$$

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[1]The major difference between equation (4.3) and the Brennan derivation
is that Brennan assumed free stocks (and reserve stocks implicitly) to be
exogenous.

where:

QP = quantity of grain placed in the reserve

QR = quantity of grain redeemed from the reserve.

To the eligible farm producer, the FOR represents another marketing option for his grain. As such, the demand for grain for placement into the program is likely to be quite responsive to the returns to the other marketing alternatives that exist. In the simplest case in which the producer is confronted with only a cash sale decision versus a placement decision, the current market price defines the opportunity cost of the placement decision. All else equal, as the market price rises, the demand for grain placements falls. In this context, and given that the amount of grain that may enter the program is constrained by current production, the demand for placements may be characterized as:

$$QP_t = h_1(P_t, X_t) \tag{4.8}$$

where:

$$h_{11} < 0, \quad 0 < h_{12} < 1$$

As prices rise to the release level, reserve stocks are triggered and may come back on the market. The higher price rises, the larger is the quantity of grain redeemed, as producers liquidate their contracts and take advantage of the high prices. The total amount of grain coming out of the program is constrained by the level of beginning reserve stocks. The demand

for redemptions, thus appears as:

$$QR_t = h_2(P_t, R_{t-1})$$ (4.9)

where:

$$h_{21}, h_{22} > 0$$
$$0 < h_{22} < 1$$

The identity in (4.7) can be restated in a behavioral form by substituting in the functional relationships for the quantity placed, and quantity redeemed in equations (4.8) and (4.9), respectively:

$$R_t = R_{t-1} + h_1(P_t, X_t) - h_2(P_t, R_{t-1})$$ (4.10)

or

$$R_t = R_{t-1} + f_4(P_t, X_t, R_{t-1})$$ (4.11)

where:

$$f_{41} < 0, \quad f_{42} > 0, \quad f_{43} < 0 \quad .$$
$$0 < f_{42} < 1$$
$$-1 < f_{43} < 0.$$

Equation (4.11) is the form used in the model. It postulates ending reserve stocks as a negative function of market price, a positive function of production (when the reserve is not in release), and a positive function of beginning reserve stocks. Although for simplicity the model treats the slope with respect to price as fixed, there may indeed be a kink in the function at the price where the change in reserve quantities is zero.

Furthermore, the effect of beginning reserve stocks on ending stocks will vary depending on whether the reserve is in or out of release.

The last behavioral relationship in the model (Equation 4.5) expresses next year's production as simply a function of the expected price. The specification of the equation assumes away any difference between actual and planned production.

Totally differentiating each equation of the model then yields:

$$dD_t = -f_{11}dP_t + f_{12}dZ_t \qquad (4.12)$$

$$dI_t = f_{21}d(P^e_{t+1} - P_t) - f_{22}dR_t + f_{23}d(X_t + I_{t-1}) \qquad (4.13)$$

$$dP^e_{t+1} = -f_{31}d(X_{t+1} + I_t) - f_{32}dR_t \qquad (4.14)$$

$$dR_t = dR_{t-1} - f_{41}dP_t + f_{42}dX_t - f_{43}dR_{t-1} \qquad (4.15)$$

$$dX_{t+1} = f_{51}dP^e_{t+1} \qquad (4.16)$$

$$dX_t = dD_t + dI_t + dR_t - dI_{t-1} - dR_{t-1} \qquad (4.17)$$

where:

$$0 < f_{22}, \ f_{23}, \ f_{42}, \ f_{43} < 1$$

$$0 < f_{23} + f_{42} < 1$$

$$f_{32} < f_{31}$$

$$f_{42} = 0 \ \text{if} \ QP_t = 0$$

$$f_{43} = 0 \ \text{if} \ QR_t = 0.$$

Most of the coefficient restrictions above originate from the market clearing identity (4.17). The identity itself allows one to constrain the coefficients f_{23}, f_{42}, f_{43}, and $f_{23} + f_{42}$ to the zero-one range. The coefficient f_{22}, which reflects the substitution effect, lies in the

range for reasons noted earlier. The coefficient f_{32} is hypothesized less

in magnitude than f_{31}, since it is assumed that market participants perceive

farmer-owned reserves as partially insulated from the market. Because the

price must rise above the release level to trigger reserves, their presence

has less of an impact on expected price than current production plus carryin

stocks which are readily available to the market.

Reduced Form Price Impacts

The static price response of the FOR model and a free market model to

the previously mentioned demand and supply shocks can now be investigated.

Impact multipliers derived from the reduced form are used to examine the

price adjustments as the markets equilibrate following each shock. The

multipliers for the demand and supply side shocks in the FOR model,

respectively, are (assuming $dI_{t-1} = dR_{t-1} = 0$):

$$\frac{dP^{FOR}}{dZ} = \frac{F_0}{F_2} \qquad \frac{dP^{FOR}}{dX} = -\frac{F_1}{F_2} \tag{4.18}$$

where:

$$F_0 = f_{12}(1+f_{31}f_{51}+f_{21}f_{31}) \tag{4.19}$$

$$F_1 = [1+f_{42}f_{22}-(f_{23}+f_{42})](1+f_{31}f_{51})+(1-f_{42})f_{21}f_{31}+f_{42}f_{21}f_{32} \tag{4.20}$$

$$F_2 = f_{41}[(1-f_{22})(1+f_{31}f_{51})+f_{21}(f_{31}-f_{32})]+(f_{11}+f_{21})(1+f_{31}f_{51})+$$
$$f_{11}f_{21}f_{31} \tag{4.21}$$

Using the a priori coefficient restrictions, it can be easily demonstrated

that F_0, F_1, and F_2 are all greater than zero.

The corresponding set of multipliers depicting the free market response, can be derived from those of the FOR model by constraining all FOR-associated parameters in the above equations to zero. To utilize this approach is to necessarily assume that the underlying parameters describing a free market structure are identical to those describing the structure of the FOR-influenced market. This assumption is tantamount to the assumption of no "parametric drift" in the Lucas (1976) sense. While potentially unjustifiable in empirical exercises, the assumption is employed here as more a matter of necessity than convenience, and is not felt to invalidate the results.

The free market multipliers are then:

$$\frac{dP^{Free}}{dZ} = \frac{F_0'}{F_2'} \qquad \frac{dP^{Free}}{dX} = -\frac{F_1'}{F_2'} \qquad (4.22)$$

where:

$$F_0' = f_{12}(1+f_{31}f_{51}+f_{21}f_{31}) \qquad (4.23)$$

$$F_1' = (1-f_{23})(1+f_{31}f_{51})+f_{21}f_{31} \qquad (4.24)$$

$$F_2' = (f_{11}+f_{21})(1+f_{31}f_{51})+f_{11}f_{21}f_{31} \qquad (4.25)$$

Similarly F_0', F_1' and F_2' are all greater than zero.

Collecting terms, we find that:

$$F_0' = F_0$$
$$F_1' = F_1 + h_1$$
$$F_2' = F_2 - h_2$$

where:

$$h_1 = f_{42}[(1-f_{22})(1+f_{31}f_{51})+f_{21}(f_{31}-f_{32})] > 0 \qquad (4.26)$$

$$h_2 = f_{41}[(1-f_{22})(1+f_{31}f_{51})+f_{21}(f_{31}-f_{32})] > 0 \qquad (4.27)$$

Therefore,

$$\frac{dP^{FOR}}{dZ} = \frac{F_0}{F_2} < \frac{F_0}{F_2-h_2} = \frac{dP^{Free}}{dZ} \qquad (4.28)$$

and

$$\left| \frac{dP^{FOR}}{dX} \right| = \frac{F_1}{F_2} < \frac{F_1+h_1}{F_2-h_2} = \left| \frac{dP^{Free}}{dX} \right| \qquad (4.29)$$

Equations (4.28) and (4.29) indicate that the externally generated market shocks assumed here, exert less of an impact on the equilibrium price in the simple FOR model, than in the model representing the free market. These equations also imply, as might be expected, that the effectiveness of the program in stabilizing prices is directly related to the price responsiveness of the demand for reserve stocks (f_{41}), and to the response of program placements to current production (f_{42}). The more price responsive are reserve quantities, the more demand and/or supply side instabilities are absorbed by changes in reserve quantities, thus lessening the equilibrium price adjustments. By similar reasoning, the larger is f_{42}, the more an exogenous increase in production is absorbed in reserve stocks, thereby diminishing the potential for a drastic fall in prices. The magnitude of the coefficient f_{42} varies mainly with changes in the number of

eligible producers. The effectiveness of the program is clearly impaired if few producers are eligible, or for that matter, if those that are eligible are hesitant to make the potential three year committment of placing grain in the program.

The above equations further imply that the performance of the program is quite sensitive to the values taken by the reserve-free stock interaction parameters, f_{22} and f_{32}. Large values for these parameters imply that reserve stocks heavily displace free, or speculative stocks, through the substitution and expectation effects mentioned earlier, translating into a diminished ability of the program to stabilize markets. If there exists a perfect farm-level substitution of reserves for free stocks (i.e., $f_{22}=1$), the stabilizing potential of the program is reduced, but not nullified as long as reserve quantities are perceived by market participants as somewhat insulated from the market (i.e., $f_{32} < f_{31}$). It is likely that as the market price approaches the release level, triggering reserve stocks, f_{32} will approach f_{31}.

FOR Effect on the Elasticity of Total Demand

The ability of the FOR to moderate price variation can be linked directly to its ability to increase the price responsiveness of total stocks (free and reserve), and hence, the elasticity of total demand. All else equal, as total demand becomes more elastic, the equilibruim price response to market instabilities is diminished.

To contrast the price responsiveness of total demand in the FOR model to that in the free market model is a simple exercise in the analysis. In the FOR model developed here, the total market demand (TD_t^{FOR}) is the sum of

the demands for current consumption, free inventories, and farmer-owned

reserves. As such, its slope with respect to the market price can be shown

to equal:

$$\frac{dTD^{FOR}}{dP} = -\frac{F_2}{F_3} \qquad (4.30)$$

where:

F_2 = as defined in (4.21)

$F_3 = 1 + f_{21}f_{31} + f_{31}f_{51}$

Correspondingly, the slope of total demand with respect to price for the

free market is:

$$\frac{dTD^{Free}}{dP} = -\frac{F_2 - h_2}{F_3} \qquad (4.31)$$

where:

h_2 = as defined in (4.27).

Given the a priori restrictions outlined earlier which guarantee that the

values for F_2, h_2, and F_3 are unambiguously positive, then clearly:

$$\left| \frac{dTD^{FOR}}{dP} \right| = \frac{F_2}{F_3} > \frac{F_2 - h_2}{F_3} = \left| \frac{dTD^{Free}}{dP} \right| \qquad (4.32)$$

As expected, the demand function in the FOR model is more price sensitive than that in the free market model, thus suggesting that the presence of the program alters the market's behavior and structure.

The implications of equation (4.32) on potential price variability are illustrated in Figure 4.1. Depicted in this diagram are the FOR and free market price responses to an exogenous production shock. Prior to the production shock in the example, both markets are equilibrated at the price P_0. As production increases, shifting total supply from S_0 to S_1, the shock in the FOR model is more rapidly absorbed in total stocks, with the result that the price falls only to P_1 before a new equilibrium is established and supply and demand are once again equated. In the free market case, however, the market price is much more sensitive to the shock, falling to P_2, before the market clears. The reserve program, by increasing the price response of the demand for stocks, lessened the price impact of the production variability. Similar results could be shown to exist in the event of a demand side shift.

While the stabilizing potential of the FOR program can be couched solely in terms of its ability to increase the elasticity of total demand, the degree to which the program is able to achieve this increase is crucially dependent on the tradeoffs that exist between the demand for reserve stocks of grain and the demand for speculative stocks. The more reserve stocks displace speculative stocks, the more a price-induced increase in speculative stocks (as above) would be curtailed by the simultaneous expansion of reserves, reducing the effectiveness of the program.
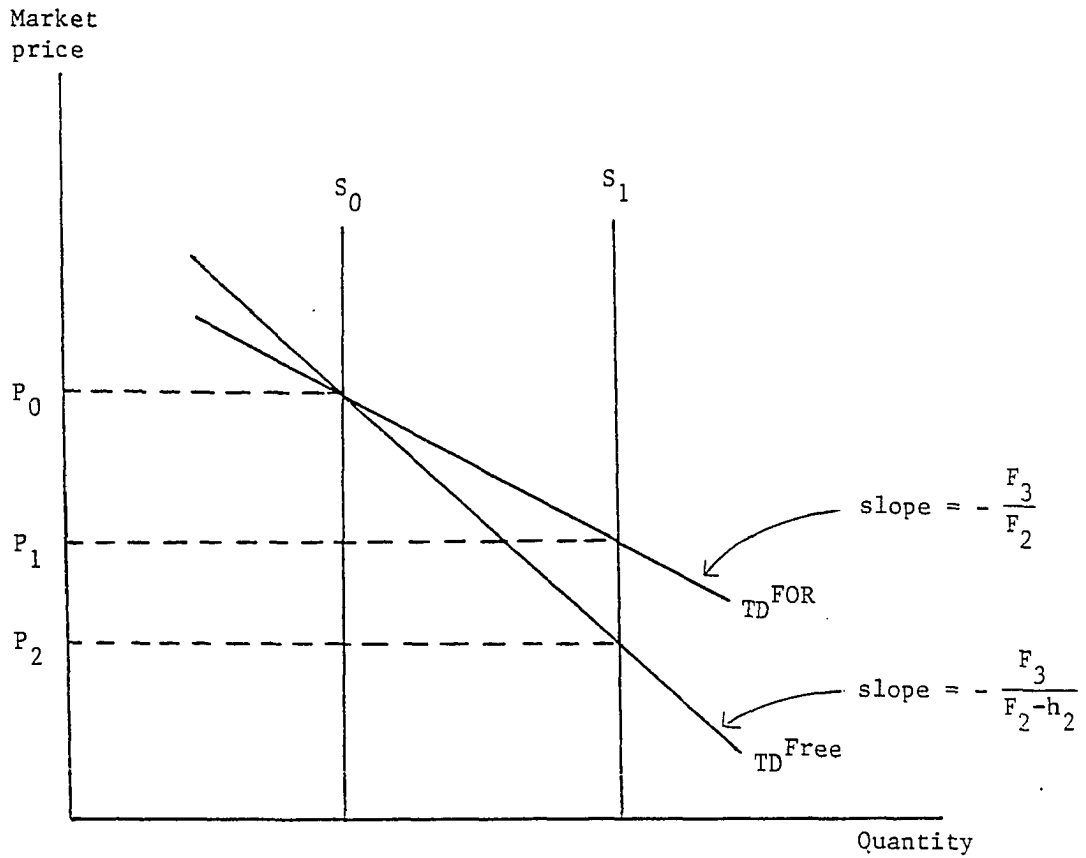
Market
price

Figure 4.1. FOR and free market price responses to an
exogenous supply shift

In the framework here, a change in reserve quantities imparts shift effects on both the supply of storage and the demand for storage. The overall impact of reserve quantities on privately held free stocks, can thus be derived by simultaneously solving equations (4.2), (4.3), and (4.5) for I_t, and differentiating the resulting partial reduced form equation with respect to R_t, yielding:

$$\frac{\partial I_t}{\partial R_t} = - \frac{f_{22}(1 + f_{31}f_{51})}{1 + f_{21}f_{31} + f_{31}f_{51}} + \frac{f_{21}f_{32}}{1 + f_{21}f_{31} + f_{31}f_{51}} \qquad (4.33)$$

The first term in the right hand side of the equation embodies the substitution effect, while the second term represents the price expectation effect.

Rearranging the terms of the h_2 expression in equation (4.27), and making use of equation (4.33) gives:

$$h_2 = f_{41} \left[1 + \frac{\partial I}{\partial R} \right] \qquad (4.34)$$

It is generally assumed that a bushel of grain placed in the FOR reduces privately-held free stocks of grain by an amount less than one bushel. That is:

$$-1 < \frac{\partial I}{\partial R} < 0 \qquad (4.35)$$

As Sharples (1982) mentions, this could in part be due to the fact that farmers are now getting paid to store grain -- most of which they would have stored anyway. In addition, only part of the grain placed in the program is acquired from free stocks, the remainder of which originates from reduced farmer marketings during the period. Under this assumption, the value for h_2 is positive, and it follows from equation (4.32) that prices will fluctuate less in the presence of the FOR than in its absence. However, if an increase in reserves displaces an equal amount of free inventories, then:

$$\frac{\partial I}{\partial R} = -1 \qquad\qquad (4.36)$$

and the term h_2 vanishes, resulting in a complete nullification of any price stabilizing characteristics of the program. In this event, the FOR-influenced market would react to a price shock in much the same manner as would a free market, the only difference being the composition of total grain stocks.

CHAPTER V. STRUCTURAL CHARACTERISTICS OF THE U.S.

CORN-LIVESTOCK SECTOR

The development of econometric models is greatly facilitated by the maintenance of a sound perspective on the structural characteristics of the system under investigation. An examination of the economic interactions that characterize the U.S. corn-livestock subsector, as well as technical and production constraints unique to the subsector, is undertaken in this chapter as a preliminary step to model formulation. The purpose is to give a balanced overview of those aspects of the subsector that may be significant to an econometric effort.

Overview of the U.S. Corn Market

Corn is one of the most important cash crops grown in the United States being the leader in terms of overall production, and the second leading crop in terms of farm receipts. Corn markets also provide the primary linkage between the crop and livestock sectors of U.S. agriculture.

The structural features and characteristics of the U.S. corn market have been discussed in detail in a report by Leath et al. (1982). Those characteristics important to this study are summarized below.

Corn supply

The United States is the world's leader in the production of corn, with the annual crop generally exceeding 25 percent of the world total. Due to a steady upward trend in corn yields per acre, production is further

increasing at an acreage rate of 200 million bushels per year (Liu 1983, p.22).

The annual U.S. supply of corn consists of production and carryover stocks. Imports are very small and do not significantly effect total supply.

Corn acreage   Dent or field corn is the predominant type of corn grown in the United States. White corn is of much lesser importance and has become a specialty crop grown for food uses. The production of white corn has not exceeded 40 million bushels since 1975.

Most corn in the U.S. is planted between late April and early May. The corn acreage planted for all purposes has exhibited sizable variations over time (Figure 5.1). During the fifties, the planted area trended downward until acreage controls were relaxed in 1959 and 1960. In the sixties and early seventies, the acreage planted stabilized at around 67 million acres. However, with no acreage controls from 1973 to 1977, the planted area increased 26 percent, and has exceeded 81 million acres eight of the last nine years. In 1983, the area planted to corn was drastically reduced by acreage cutbacks under the payment-in-kind (PIK) program.

Corn acreage planted is largely a function of participation in government programs, and expected market prices for corn and soybeans. Soybean prices are a factor because on most land both crops can easily be substituted for each other, depending on which will yield a higher expected profit.

The harvest of corn begins in September and generally carries through October. The proportion of planted acreage actually harvested varies closely with weather conditions. High temperatures and lack of

Mil. acres
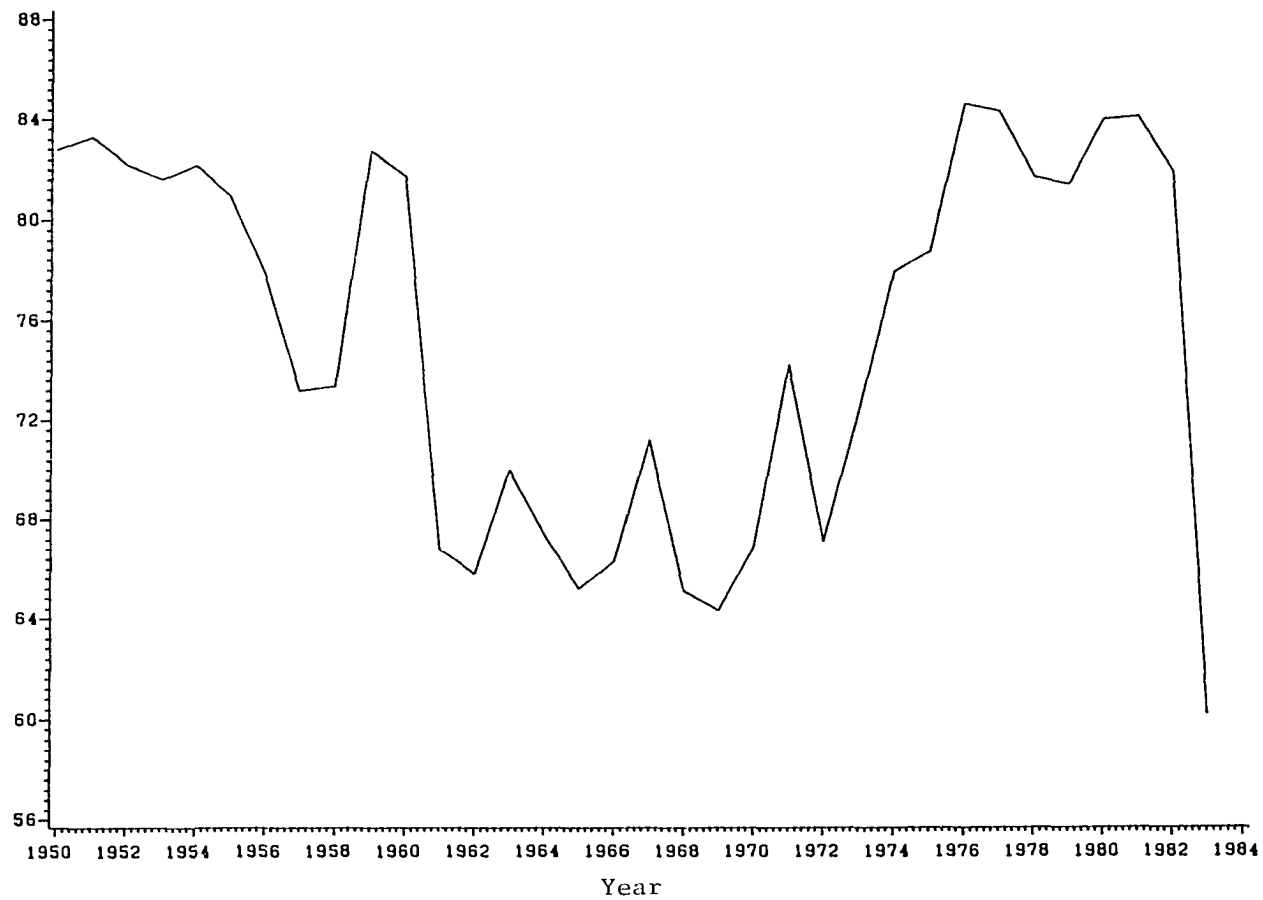
Figure 5.1.   U.S. corn planted acreage

precipitation during the growing season result in more corn acreage harvested early for silage. The acreage harvested as silage has almost doubled since 1950, and averages around 11 percent of total corn acreage planted.

Yield per bushel   Corn yields per harvested acre increased 200 percent from 1950 to 1982. The most significant increases took place in the fifties and sixties. Yields increased at a much slower rate in the seventies when marginal, less productive land was placed in production.

The general increase in yields over time (Figure 5.2) is primarily the result of changes in technology and production practices, including development of improved high yielding hybrids, increased rates of fertilization, higher seeding rates, and improved control methods for weeds, insects, and diseases. The greater variability in yields which occurred during the seventies evolved primarily from the weather.

Total production   While acreage has varied significantly from year to year, total production of corn has trended upward. In spite of the fact that the acreage harvested in 1982 was about the same as that harvested in 1950, yield increases in that time tripled production from 2.8 billion bushels to 8.4 billion bushels.

The Corn Belt is the primary corn producing area, accounting for over 45 percent of total acreage planted and over 55 percent of total U.S. production. The region's share of both the total production and harvested acreage for the U.S. increased slightly from 1960 to 1970, but decreased somewhat in the early eighties. Although the Corn Belt has led all regions in production, the Lake States region has shown the greatest increase in

Figure 5.2. Average U.S. corn yield per harvested acre

acreage and production. The Lake States region surpassed the Northern
Plains during the seventies and currently ranks second among all regions in
corn production. The Southeast and Delta States during the same period saw
their regional shares of production and harvested acres decrease -- largely
the result of a substitution of more profitable crops such as soybeans.

Carryover   Carryover stocks are inventories of corn remaining in
storage at the end of the marketing year on September 30. With the
exception of government-related stocks, carryovers represent working
inventories and excess supplies required by processors, exporters, and
livestock feeders in the transition from one marketing year to the next.
Table 5.1 shows the breakdown of total U.S. carryover stocks of corn
together with the other sources of corn supply for the period since 1966.

As may be seen in the table, variations in carryover stocks have been
quite pronounced, with ending stocks of corn ranging from 361 million
bushels in 1975 to over 3.1 billion bushels in 1983. The variation in total
stocks largely reflects changes in government-related inventories, which
include stocks owned by the CCC, as well as farmer-owned quantitites under
the CCC and FOR loan programs.

Government-related stocks as a percent of total stocks tend to be
inversely related to crop prices. Responding to the high prices of the mid
seventies, government-owned and program stocks fell to one percent of total
stocks in 1975. However, low prices in the eighties made quite attractive
the respective government loan programs, tying up 94 percent of total stocks
in government-related inventories by the end of the 1982/83 year. Privately

Table 5.1. U.S. corn supply, 1966/67-1983/84

| Marketing year | Beginning of year stocks | | | | | Production | Imports | Total Supply |
| | Free stocks | | | | | | | |
	Not under loan	Under CCC loan	Farmer owned reserve	CCC owned stocks	Total			
	- - - - - - - - - - million bushels - - - - - - - - - - - -							
1966/67	245	348	0	249	842	4168	1	5011
1967/68	454	235	0	138	826	4860	1	5687
1968/69	453	533	0	182	1169	4450	1	5620
1969/70	381	442	0	295	1118	4687	1	5806
1970/71	404	346	0	255	1005	4152	4	5161
1971/72	324	238	0	105	667	5646	1	6314
1972/73	403	564	0	160	1126	5580	1	6708
1973/74	539	90	0	79	709	5671	1	6380
1974/75	471	5	0	7	484	4701	2	5187
1975/76	358	3	0	0	361	5841	2	6204
1976/77	376	23	0	0	400	6289	2	6691
1977/78	738	148	0	0	886	6505	3	7394
1978/79	368	415	316	13	1111	7268	1	8380
1979/80	539	116	550	100	1304	7939	1	9244
1980/81	642	83	636	256	1618	6645	1	8264
1981/82	424	187	185	238	1034	8201	1	9237
1982/83	265	309	1310	302	2186	8397	1	10684
1983/84	197	100	1656	1166	3119	4121	1	7241

held stocks not under loan tend to be much more stable than government inventories, and primarily reflect working inventories required by the users of corn.

No major trends are observable in the position of corn stocks over time (Table 5.2). Stocks held on the farm are relatively stable and constitute around 60 percent of total ending stocks, the balance of which is maintained in commercial storage facilities. As indicated in the table, the CCC held a sizable portion of its stocks at CCC binsites until 1973 when the binsite

Table 5.2. Ending stocks of corn, by position, 1965/66-1983/84

Marketing year	Farm	Off-farm[a]	CCC binsites	Total
		million bushels		
1965/66	532	176	134	842
1966/67	572	156	98	826
1967/68	788	277	104	1169
1968/69	732	243	143	1118
1969/70	576	318	111	1005
1970/71	427	215	25	667
1971/72	751	349	26	1126
1972/73	405	284	20	709
1973/74	288	196	0	484
1974/75	192	169	0	361
1975/76	234	166	0	400
1976/77	448	438	0	886
1977/78	666	445	0	1111
1978/79	795	509	0	1304
1979/80	921	697	0	1618
1980/81	490	544	0	1034
1981/82	1356	830	0	2186
1982/83	1510	1609	0	3119
1983/84	347	375	0	722

[a]Includes corn stored in interior mills, elevators, and warehouses.

storage program was discontinued. These stocks are now entirely held at commercial facilities.

Corn demand

Domestic corn use currently accounts for about three-fourths of total annual disappearance (Table 5.3). Livestock and poultry feed is the largest source of disappearance accounting for between 83 to 91 percent of total domestic use. Although much smaller, industrial uses of corn (food, industry, and alcoholic beverages) has grown at a faster rate, increasing

Table 5.3. U.S. corn disappearance, 1966/67-1983/84

Marketing year	Domestic use					Exports	Total disappearance
	Food and industry	Alcoholic beverages	Seed	Feed	Total		

- - - - - - - - - - - million bushels - - - - - - - - - - -

Marketing year	Food and industry	Alcoholic beverages	Seed	Feed	Total	Exports	Total disappearance
1966/67	282	73	14	3323	3697	487	4184
1967/68	291	74	13	3524	3886	633	4519
1968/69	272	75	12	3607	3966	536	4501
1969/70	278	74	13	3825	4190	612	4801
1970/71	299	69	17	3593	3978	517	4495
1971/72	324	70	15	3982	4391	796	5187
1972/73	359	75	16	4292	4742	1258	6000
1973/74	374	80	18	4181	4653	1243	5896
1974/75	412	66	19	3180	3677	1149	4826
1975/76	432	71	20	3570	4093	1711	5804
1976/77	456	74	20	3571	4121	1684	5805
1977/78	500	70	20	3744	4334	1948	6282
1978/79	531	69	20	4324	4944	2133	7077
1979/80	583	72	20	4518	5193	2433	7626
1980/81	642	73	20	4133	4868	2355	7223
1981/82	709	83	19	4202	5013	1967	6980
1982/83	774	109	15	4522	5420	1870	7290
1983/84	864	92	19	3875	4850	1850	6700

almost 50 percent from 1979 to 1983. Corn exports since the early seventies have become an important market channel averaging over 28 percent of total disappearance in the last decade.

Livestock and poultry feed   Corn accounts for about 80 percent of the total quantity of grain fed to livestock in the United States. As a feed, corn use in the last thirty years has ranged from a low of 2.2 billion bushels in 1954/55 to a record high of 4.8 billion bushels in 1982/83. The variation in feed use reflects changes in the number of animals on feed, as

well as ration adjustments by livestock and poultry producers in response to relative prices of corn and competing feed ingredients.

A sizable proportion of the number of cattle and hogs in the U.S. are located on grain producing farms. As a result, about 60 percent of the corn used as animal feed is fed on the farms where produced. The balance is purchased from nonfarm sources as whole corn or in prepared animal feeds. Prepared animal feed manufacturers use corn byproducts produced by dry-corn millers (hominy feeds), wet-corn processors (corn gluten meal and corn gluten feed), and distillers (distiller's dried grain).

Demand for corn by livestock and poultry producers is quite seasonal, peaking in the fall and winter. Feed use is usually the lightest during the summer reflecting in part, a greater use of wheat when prices are at a seasonal low. The most important determinants of the quantity of corn used for feed are: the price of corn, the price of soybean meal, the value of beef, pork, and broiler production, the quantity of wheat fed, and the price received by farmers for livestock and livestock products.

The hog industry is the largest user of corn, with an average consumption of 37 percent of total corn fed over the last eight years. Cattle on feed and other beef cattle over the same period accounted for about 26 percent of the quantity of corn consumed by livestock. The poultry and dairy industries accounted for 20 percent and 17 percent of consumption, respectively.

While the consumption shares have been fairly stable on a year to year basis, several trends have surfaced in the last decade. The poultry industry for example, has increased its share of corn consumption from 18 percent of total corn fed in 1975/76 to 22 percent in 1982/83. The

expansion in feeding corn to poultry has occurred at the expense of the

cattle on feed industry which over the same period decreased its consumption

share from 24 to 19 percent. The demand for corn as an ingredient in hog

rations has similarly diminished the last five years, from 39 percent to 34

percent of total usage. Use by the dairy industry has exhibited a slow but

upward trend, reflecting a more stable price structure for dairy products

compared with other livestock products.

Food, seed, and industry   Domestic use of corn for food, seed, and

industrial (FSI) purposes has been relatively small compared with the annual

volume used for livestock and poultry feed, but has increased at a much more

rapid rate. Most of the corn moving into FSI uses is processed by either

the wet-corn processing industry or the dry-corn milling industry. A large

proportion of the primary products of these industries (meal, grits, flour,

and starch) is further processed into breakfast foods, corn sweetener

products, ethanol alcohol, pet foods, and other products.

The fifties and sixties were periods of slow but rather steady growth

in the quantity of corn used for FSI purposes, with annual growth rates

averaging about 2.5 percent. In the seventies, however, as a result of

expanding markets for sweetener products, FSI use jumped from 7.5 percent to

13 percent of total domestic corn use. From 1979 on, FSI use rose at a rate

of 10 percent per year, reflecting the increased use of corn and corn

products in the production of subsidized alcohol fuels, in addition to corn

sweeteners.

Most of the corn used for FSI purposes is channeled to the wet

processing industry. In 1950, wet processed products accounted for 50

percent of total FSI use rising to 70 percent in 1980. A large part of the gain was attributed to the production of high fructose corn syrup (HFCS). Since the early seventies when the industry first produced it, per capita consumption of HFCS has doubled as large commercial users substitute more fructose for sugar in satisfying their sweetener needs. The major users are soft drink manufacturers who now use fructose for over half of their sweetener requirements.

The other major FSI user of corn is the dry-milling industry. Dry millers use corn in the production of breakfast foods, brewer's grits, and other food products such as cornmeal, hominy grits, and corn flour. Production of dry-milling products has increased more slowly than wet-processed products reflecting the rather stable per capita consumption of meal and cereal in recent years.

Exports   Exports of corn are the second largest component of total U.S. corn disappearance. Exports have had a significant impact on U.S. corn markets in recent years. The price instability of the last decade reflects the variability in exports as well as variability in domestic production.

During the fifties and sixties, corn exports accounted for an average 5 percent and 12 percent of total disappearance, respectively. However, exports began to expand rapidly in the early seventies. In 1973/74, more than 1.2 billion bushels of corn was exported, representing a 143 percent increase in only two years. Corn exports continued to trend upward through the seventies to a record 2.4 billion bushels in 1979/80, representing 32 percent of total disappearance. The growth in U.S. corn exports during the seventies translated into an increase of from 42 percent of the world corn

trade in 1970 to 70 percent of the world corn trade by 1980. Since 1980, U.S. corn exports as well as trade share have fallen off moderately.

The U.S. ships corn to more than ninety countries, primarily for use in livestock feeds. Western Europe and Japan have traditionally been the major importers followed by the Soviet Union and Mexico. However, several recent trends in U.S. corn exports by destination have emerged, shifting the importance of the major importers.

In the past, Western Europe has been the leading destination for U.S. exports of corn, accounting for more than 50 percent of U.S. shipments as recently as 1976/77 (Figure 5.3)[1]. However, in the past five years, Western European countries have sharply reduced their purchases of U.S. corn. The trend in exports to this region largely reflected increased domestic grain supplies in the countries, as well as the substantial use of grain substitutes such as corn gluten feeds and soybean meal. The European Community does not apply its variable levy system to imports of these products resulting in their availability to feed manufacturers at more attractive prices than imported corn.

The void created by smaller corn exports to Western and additionally, Eastern European countries has partially been filled by rapidly expanding shipments to Asian and Latin American destinations. Japan is by far the leading destination among Asian countries accounting for over 50 percent of shipments to the region. Other significant importers in the area include

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[1]EC-10 in the figure denotes the ten member countries of the European Community, while LDC denotes "less developed countries." OTHER is the residual of U.S. corn exports.
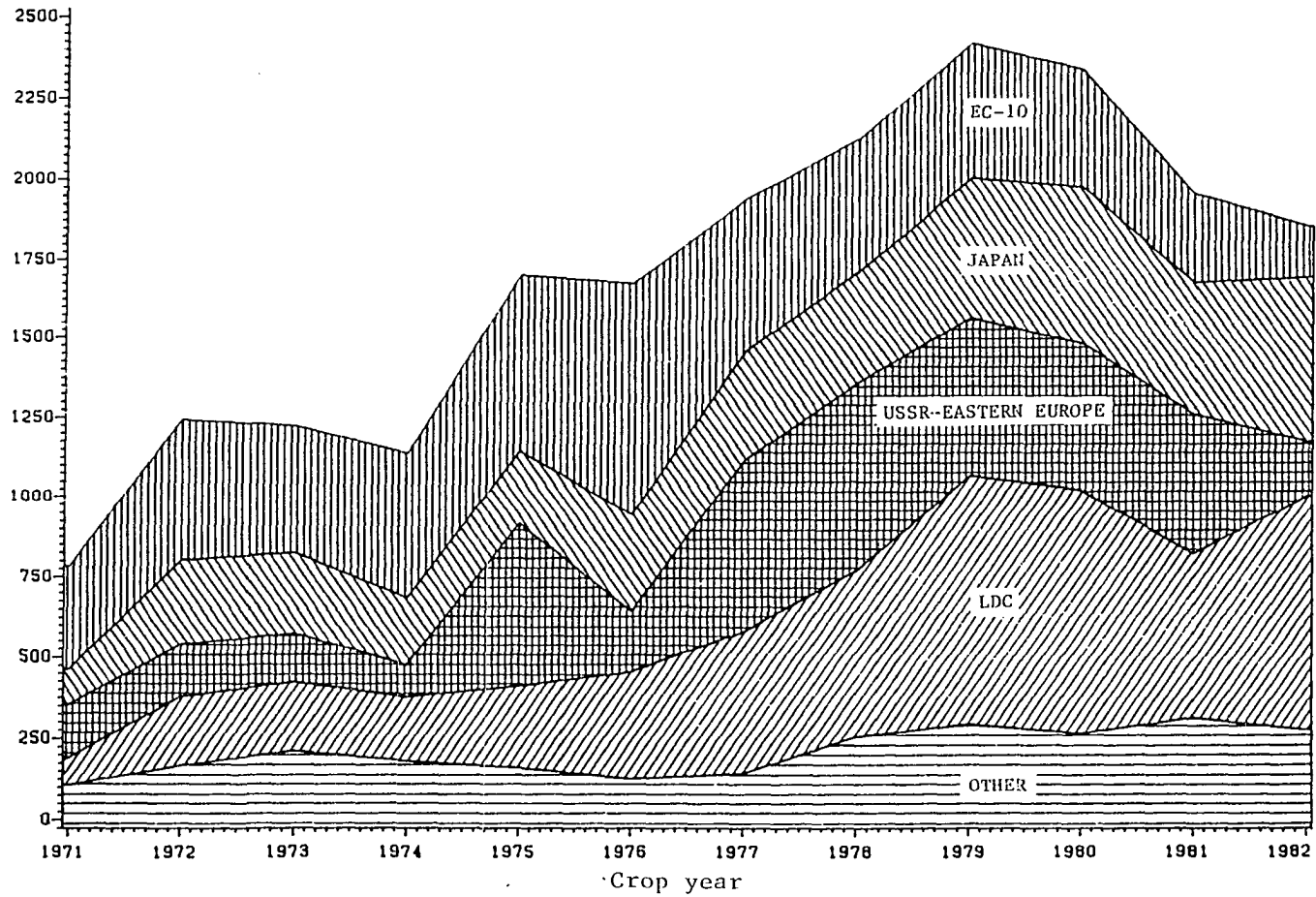
Mil. bu.

Figure 5.3. U.S. corn exports by destination

the Republic of Korea, Taiwan, and the People's Republic of China. Mexico has shown the sharpest rate of increase among Latin American countries.

U.S. exports of corn at 60-70 percent of world trade, far overshadow those of any other major grain trading nation -- even at their recently reduced level. Argentina, the second largest exporter, accounts for around 12 percent of the world trade, followed by Canada and South Africa at 7 percent each, and Thailand, Western Europe, and Australia at 3 percent each. Although not a monopoly, the United States, by virtue of its large share of the world corn trade, is a major influence on world prices.

The value of the dollar relative to foreign currencies, production by other exporters, importer livestock numbers and trade policies are the major factors to be considered in modeling the annual volume of U.S. corn exported.

Overview of the U.S. Beef, Pork and Broiler Markets

Beef production

Beef production in the United States can be divided into two specialized stages: (1) feeder calf production and (2) cattle feeding.

Feeder calf production   Beef cow herds are maintained on farms as an investment in the production of feeder calves. After weaning, feeder calves may either be marketed as a source of immediate output, or retained through the feeding stages and marketed for slaughter. Seventy percent of U.S. farms and ranches engaged in beef production are considered cow-calf operations, marketing most of their calves at weaning or shortly thereafter (Boykin et al., 1980).

The most popular time for calving in cow-calf operations is the late winter to early spring months, although there is a growing trend towards

fall calving. Under normal circumstances, calves born in the early spring months are weaned in the fall at about 7 to 8 months of age, and a weight approaching 500 pounds. Although lightweight calves may be marketed at this time, if roughages are available they may be carried longer into what is sometimes referred to as a stocker phase. Many operators sell stocker calves to feedlot operators who graze them briefly on pastures or crop residues before placing them on concentrate feeds. The period calves stay on grass prior to placement in feedlots depends on feed grain availability, and feed grain and fed cattle price relationships. If feeding margins are very poor, cattle may remain on grass or roughage-based feeds until they reach slaughter weight. Under such conditions, the period from weaning to slaughter is substantially longer.

Since beef cows are typically only an indirect source of output, it is most economical to maintain them on low-quality roughages such as rangeland, pasture, or harvested forages used to supplement grazing. While existing in all fifty states, the majority of beef cows are located in the Western Rangelands, the Corn Belt and the Southeastern States. Herds in the Western States are relatively large and comprise almost one half of the total cow herd. By comparison, cow herds in the Corn Belt States are very small at about one fifth the average size of those in the West. Cow-calf operations in the Corn Belt are frequently part of a diversified farm enterprise, combined with other operations such as corn and soybean crops, and cattle feeding or hog raising.

The number of beef cows on farms for the last two decades is illustrated in Figure 5.4. Beef cow numbers are quite cyclical, having reached a peak for the period of 45.7 million head in 1975. The number of
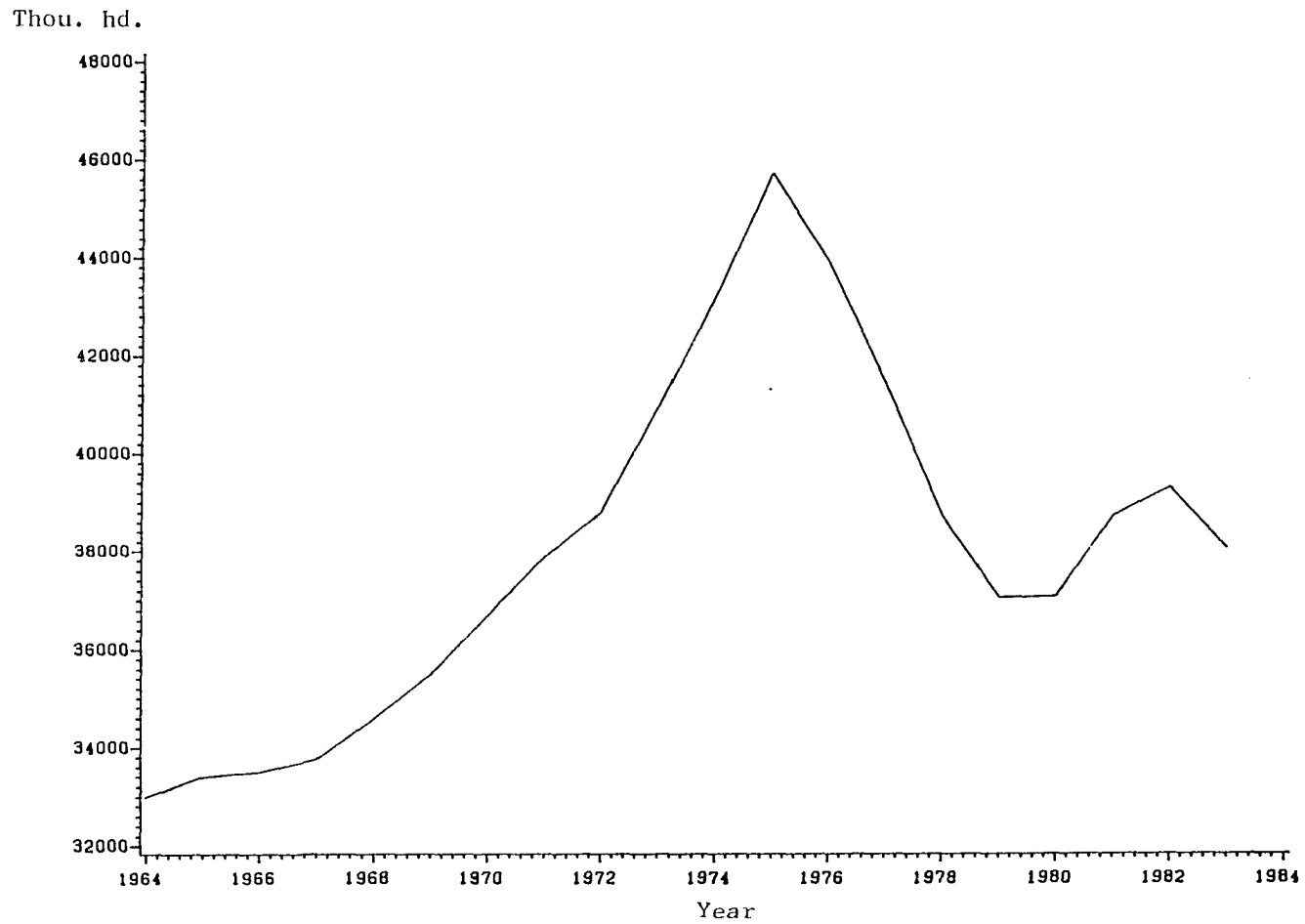
Thou. hd.

Figure 5.4. Beef cows and heifers on farms, U.S.

cows held in inventory is relatively inflexible in the current period and exhibits very little price response given the technical constraints of building herds through the retention of heifers.

Over the last twenty years, there appears to have been little structural change in calf production. The overall calving ratio, a key structural parameter, has not risen greatly above its 1965 level of 90 percent, and actually fell a little below this level during the 1975-1979 period. From 1960 to 1980, however, the slaughter of calves has fallen from 33 percent of total adult cattle slaughter to only 7.7 percent.

Cattle feeding   Feeder steers and heifers are placed on concentrate feeds to promote fattening and shorten the period to market weight. Once placed in feedlots calves are very seldom returned to roughages, however, there may be some early turnoff, and thus lighter weight marketings in times of poor feeding margins. Most calves are placed in feedlots within a few months after weaning at an average weight of 650 pounds. This characteristic results in a marked seasonal peak in placements in the fourth quarter of each year (Figure 5.5). However, much flexibility exists on the part of the cattle feeder in making the commitment to place calves on feed -- the timing of which varies with relative prices, seasonal conditions, and pasture availability. By varying the age at placement, the length of the feeding period, and the number of calves fed, producers are able to adjust the quantity of grain fed and the output of beef in response to current market signals.

The rations fed to cattle usually consist of feed grains (especially corn), a protein supplement, and some roughage in the form of hay or silage.
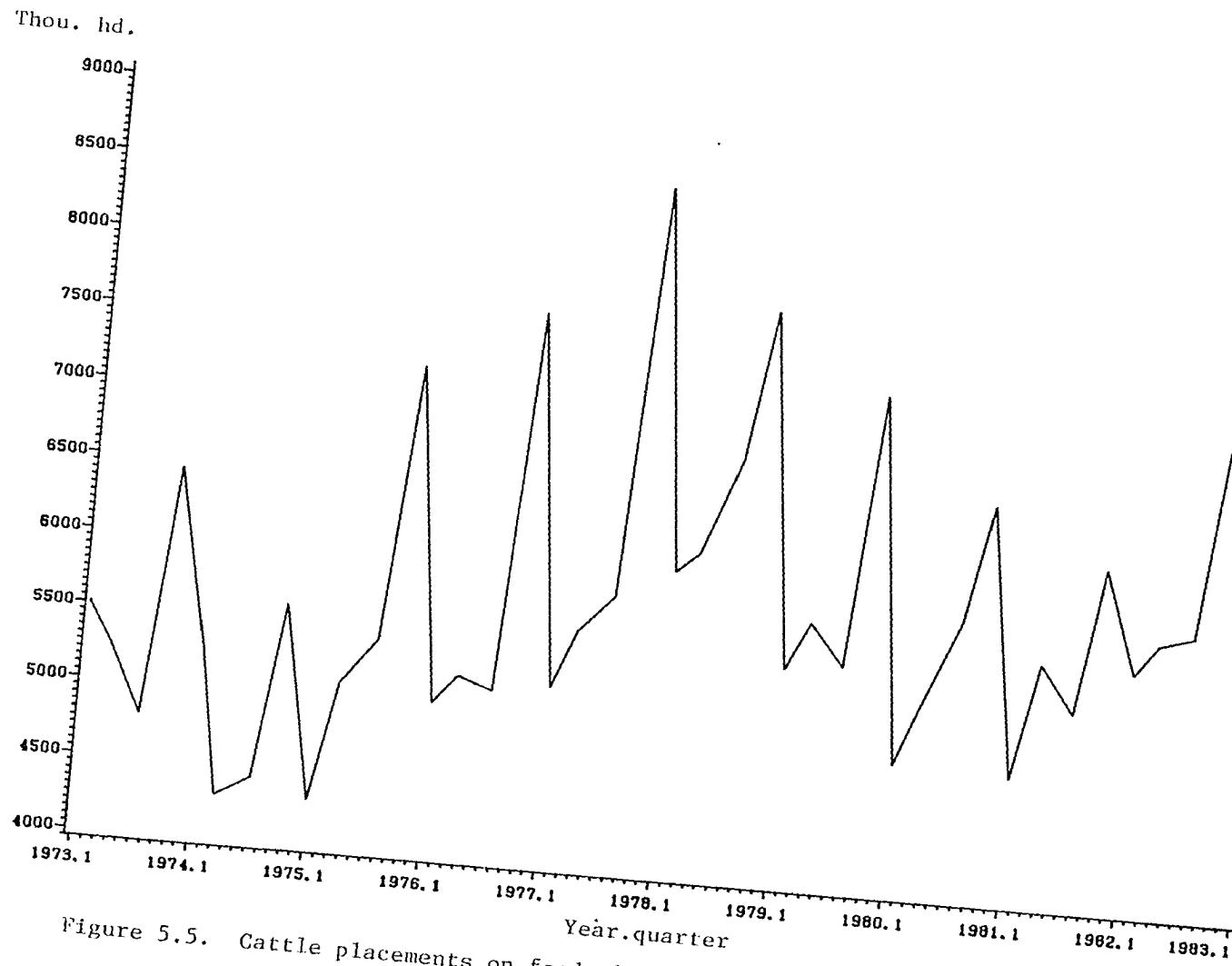
Thou. hd.

Figure 5.5. Cattle placements on feed, 13 states

85

The most important cost components in cattle feeding are the cost of the feeder calf and the feed grain component of the ration. Based on prices in 1981, the cost of the feeder calf was estimated to be 53 percent of the total cost of feeding a 600 pound calf to 1,100 pounds in the Corn Belt (USDA, 1982). Feed grains contributed an additional 20 percent, while the protein supplement comprised 5 percent of the total costs. These proportions appear to have been fairly stable through time and suggest that the key price variables in modeling cattle feeding are likely to be feeder steer and feed grain prices.

The efficiency with which feed is converted to gain for a calf in a lot depends upon the ration composition, the weight and sex of the calf, length of the feeding period, and weather. A higher level of roughages in a ration reduces the feed cost, but also reduces daily gains and feeding efficiency. Typically cattle on feed require around 11 pounds of feed per pound of gain, compared with over 16 for cattle on roughage feeds (Allen, 1976). These conversion ratios have remained very stable over time.

One prominent characteristic of U.S. beef production is the substantial westward shift in cattle feeding operations over the last two decades. This shift has been accompanied also by a movement towards larger, commercialized feedlots, and fewer farmer-operated feedlots. In 1977, only two percent of all feedlots had a capacity of greater than 1000 head, yet these lots produced 65 percent of all the fed beef slaughtered (Gee et al., 1979). Large commercial operations tend to market cattle continuously throughout the year, while farm feedlots generally market live cattle in only the late spring through summer months (Van Arsdall and Nelson, 1983). Commercial lots also feed higher concentrate rations, resulting in a shorter time on

feed and quicker turnaround. The average time on feed in large feedlots is around 150 days, compared with 225 days in farm feedlots.

Pork production

The structural characteristics of U.S. hog production have been discussed in detail by Van Arsdall and Nelson (1984), and only a few key aspects are summarized below.

Hogs and pigs are raised for the most part in three types of specialized operations: feeder pig operations, feeder pig finishing operations, and farrow-to-finish operations. While there is some overlapping, most hog producers use only one production system.

About one-fourth of all slaughter hogs are produced through the split phase production system, where they are farrowed and raised to 40-60 pounds by feeder pig producers, and then sold to feeder pig finishers for additional fattening to slaughter weight. In the feeder pig production phase, pigs are typically weaned 5-6 weeks after farrowing, and marketed to finishers at around nine weeks of age. The age at weaning bears a strong inverse relationship to the size of the operation, with larger farrowing operations weaning at less than four weeks of age so as to shorten the production turnaround and permit a more intensive use of facilities. In finishing operations, feeder pigs are fed to slaughter weight on high energy rations designed to promote weight gain. The period from market as feeder pigs to market as slaughter hogs averages around 130 days.

Three-fourths of the hogs produced are raised directly from birth to slaughter through farrow-to-finish operations. By combining the functions of the above two activities, these operations are able to raise hogs to

market weight on less fed and in about 2-3 weeks less time. In farrow-to-finish operations, producers control the number, quality, and timing of the pigs they will finish, and also avoid the costs of buying and transporting pigs, and the losses and stresses incurred in the process. Additionally, there is some evidence that the inherent performance capabilities of hogs raised in farrow-to-finish operations is greater than those produced under split operations.

Hog slaughter weights average in the 225-230 pound range, but do exhibit some price responsiveness. For example, when the hog/corn price ratio is low, as it was in 1980, slaughter weights tend to be lighter, whereas when it is high, the returns to hog feeding are larger, and hence, the weights at slaughter. Hog production is relatively evenly distributed throughout the year with little apparent seasonality.

Based on USDA estimates, the two largest expenses in hog feeding are the cost of the feeder pig, and the cost of the feed grain used in the ration (USDA, 1982). Each of these expenses accounted for 30 percent of the total feeding cost in 1981. Protein supplements account for around 18 percent of total costs.

Traditionally, hog and corn production have been companion enterprises, with farmers using hogs as an alternative means to market corn. As such, hog production is strongly concentrated in the North Central Region of the United States where corn is the major crop. Sixty-seven percent of the 1981 hog inventory was located in eight states in this region: Illinois, Indiana, Iowa, Minnesota, Nebraska, Ohio, South Dakota, and Wisconsin (USDA, 1981). Roughly two-thirds of the farms producing hogs in 1975, had

other livestock or poultry activities, with 90 percent of these farms having
beef cows or cattle feeding as that activity.

Despite sharply fewer producers, U.S. hog production remained about the
same for the period 1950-1980. However, per capita consumption of pork for
the period trended downward, largely the result of a sharp decrease in lard
consumption from 14 pounds per capita in the early fifties to only 2 pounds
per capita in the late seventies. U.S. pork producers responded to the
shift in consumer preferences by producing more "meat-type" hogs, such that
in 1980, 96 percent of all barrows and gilts graded U.S. No. 2 or better,
compared with only 50 percent twelve years earlier (Parham and Agnew, 1982).
The result was that while overall per capita pork consumption was trending
down, per capita consumption of pork meat held steady for the period. In
1980, pork represented about one-third of total U.S. red meat consumption.

Broiler production

Broilers are young chickens seven to ten weeks of age, that are raised
specifically for their meat. Prior to 1940, the production of broilers was
virtually nonexistent in the U.S. Since that time, however, in response to
consumer desires for young, tender, meat-type chickens, the broiler industry
has expanded rapidly. In 1950, the total number of broilers produced in the
U.S. was 632 million, whereas by 1980 it had risen to 3.9 billion
(Lasley, 1983, p. 13). In terms of annual per capita consumption, this
represented an increase of from 8.7 pounds to 48.6 pounds.

A large degree of vertical integration and rapid technology change have
been two key characteristics in the broiler industry the last few decades,
and have vastly improved both production and efficiency. Vertical

coordination of successive production and marketing stages through ownership

or contracting has spread rapidly such that by 1977, ninety-nine percent of

all broilers produced were grown under contract or by integrated firms.

With the increase in integration has come about a concomitant increase in

the concentration of production. For example, in 1978 the largest one-third

of all farms producing broilers were each marketing more than 100,000

broilers annually. These farms accounted for 82 percent of total

production.

Rapid technological change in the industry has significantly enhanced

feeding efficiency. Advances in production technologies, improvements in

poultry nutrition, and improved management practices have enabled the

broiler industry to produce a 3.5 pound broiler, ready for processing, in

seven to eight weeks, instead of the twelve to fourteen weeks that was

typical in 1960 (Benson and Witzig, 1977). In 1980, 208 pounds of feed were

required to produce 100 pounds of broiler meat, compared with 285 pounds of

feed required in 1960.

The cost of feed is by far the largest cost component in broiler

production, accounting for 73 percent of total production costs in 1977. A

typical broiler ration is composed of 70 percent corn and 30 percent soybean

meal (Chavas, 1978, p. 65). In this proportion, the costs of the two feed

ingredients is roughly equal.

Broiler production requires the shortest planning horizon of the

livestock markets considered here. According to Rausser and Cargill (1970),

there is a lag of around 26 days between shipment of eggs to the hatchery

and the placement of the resulting chicks in the flock. A broiler-type

chick is then typically marketed in around 55 days (Kenyon, 1981). Although

hatchery egg supply levels place a maximum constraint on the egg set potential, there is relatively little cost to excess capacity, and thus, a large degree of production flexibility exists on the down side (Paulsen et al., 1977). The minimum time span between a decision to expand or decrease production, and the actual realization of that change should therefore be approximately equal to the three months needed to convert eggs to finished broilers.

CHAPTER VI. SPECIFICATION AND ESTIMATION OF

AN ECONOMETRIC MODEL

An integrated econometric model of the U.S. corn-livestock subsector is

conceptualized and estimated in this chapter. The model will serve as the

basis for the empirical analysis of the Farmer-Owned Reserve Program for

corn that is undertaken in Chapter VIII.

Specification Issues

An econometric model is inherently a simplified approximation of

reality. The specification of such a model involves the problem of

translating hypotheses about the functioning of the system under

investigation into estimable relationships. In general, a variety of

alternative model specifications are admissible, with standard statistical

tests incapable of discriminating among them. Determinations required prior

to the specification process itself are those involving the bounds of the

model, the particular functional forms used, and for time series models, the

frequency of data observations. These issues are first taken up as

preparatory steps to imposing a parameteric structure on the model.

Degree of exogeneity

An initial specification problem to be dealt with involves

determination of those components of the system that should be included in

the model. While there are always gains to be realized by expanding the

size of the model, the limitations imposed on this activity by the costs of

information, computation, and structural understanding, favor small, less

extensive models. An objective in determining the appropriate scope of the model was to make the model as simple as possible without eroding its value as a decision aid.

For this study, the size of the model was determined by the minimum number of equations necessary to represent the system at the level of disaggregation consistent with the study's objectives. The model was delineated to include only the corn, fed beef, pork, and broiler markets in an endogenous fashion. Although the main emphasis is on corn markets, the fed beef, pork, and broiler markets were retained in the specification because of the importance of these commodities as a source of demand for corn, and because of the strong interdependencies that exist among these groups at the retail level, and to a lesser extent, the farm level.

Variables representing competing agricultural commodity markets, such as that for the other feedgrains, wheat, soybeans, lower quality processed beef, and dairy animals were regarded as predetermined to the model. The other feedgrains and wheat were excluded from consideration because they do not compete strongly with corn for production resources, and because these commodities are relatively minor feed ingredients. Consumption and production of soybeans, processed beef, and dairy products were regarded as predetermined primarily in the interests of model manageability. Unlike the other feedgrains and wheat, soybeans do compete closely with corn for production resources (land in particular), with soybean prices in part, jointly determined with corn prices. However, inclusion of the soybean market would involve modeling a complex subsystem, given the importance of the soyoil and soymeal markets in the price determination process. While

dairy animals compete with the remainder of the livestock sector for

feedgrains and grazing land, this subsector was also dropped from

consideration because of the anticipated modeling difficulties, given the

array of federal policy measures specific to the subsector. Although some

lower quality processed beef is derived from the slaughter of corn-fed

cattle, most of it comes from the slaughter of cull cows, range-fed beef,

and imported beef, and hence, is only indirectly affected by events in the

feedgrain markets.

Functional form

In general, standard economic theory offers very little guidance in the

choosing of functional forms, so that in practice the modeler has much

flexibility in choosing the exact set of structures to represent the system.

In many circumstances, the reported functional form was the end product of

an exploratory analysis, where several alternative forms were empirically

tested. Since linear models of the corn-livestock subsector have performed

well in previous studies (e.g., Arzac and Wilkinson, 1979; Martin, 1983),

the basic intent here was to retain this assumption as far as possible.

While not ruling out the possibility of nonlinear relationships, the

assumption of linearity is much more convenient from an estimation

standpoint, and is not theoretically implausible.

Periodicity

Because the FOR program is to be examined from a seasonal standpoint, a

quarterly data period was considered appropriate. Relative to annual data,

quarterly data provide additional information on the response of

decisionmaking units in the system to economic factors, but also impose

additional structural complexities on the model as attention is focused on

the specific characteristics of quarterly economic behavior which may be

different from yearly averages or totals. On the crops side for example,

where production enters the year in only the first quarter, the level of

beginning stocks in subsequent quarters represents the only source of

supply. The model must necessarily allow for an explicit treatment of the

quarter to quarter allocation of grain stocks to the various disappearances.

Moreover, the possibility exists that the price responsiveness of demand

relations and other structural equations may differ within a year. Hence,

the specification must have the functional flexibility to capture any

seasonal shifting of the price parameters.

On the livestock side, quarterly production relationships are highly

dynamic, and difficult to specify mathematically, given the technical

constraints of production response in addition to producer flexibility with

respect to feeding strategies for certain livestock groups. The highly

seasonal nature of calf crops, calf placements on concentrate feeds, and sow

farrowings require special consideration, not necessary in annual models.

Decisionmaking in the livestock subsector can be much more accurately

represented in an intrayear framework, to the extent that the model is

structured with an explicit recognition of the seasonal production, and

economic decisions that take place.

Model Structure and Estimation Procedure

The specification employed in the model was motivated by several

factors. As with any econometric effort, the primary objective was to

derive a form which would accurately represent the physical flows, component

interactions, and pricing relationships that characterize and guide the

underlying system through time. To this end, the specification is based on

the neoclassical theory of consumer and producer behavior, with

consideration given to the physical attributes of the relevant commodities,

in order to set up appropriate lag lengths relative to the biological

production periods. As part of this process, the specification necessarily

assumes economic rationality on the part of the system's participants.

In view of the model's role as a tool for policy analysis, the

specific policies questions at hand were also a factor in the model's

design. Because the objective of the study is to evaluate the impacts of

the FOR program in a market setting, a heavy emphasis was placed on modeling

the FOR, with explicit treatment of the interactions between FOR stocks of

corn and privately-held free stocks. The major livestock markets are

represented in the model not only because of the interrelationships of these

markets with corn markets, as noted earlier, but also as a means to evaluate

the economic ramifications of reserve policies on the livestock industry.

Structure of the model

The model is comprised of forty-nine equations of which twenty-two are

stochastic, and the remaining twenty-seven are market clearing or

definitional equations. Relationships among the endogenous variables of the

corn sector of the model are illustrated in Figure 6.1. In each quarter,

the corn market subsystem allocates beginning stocks and production to the

five endogenous sources of disappearance: (1) feed, (2) food, seed, and

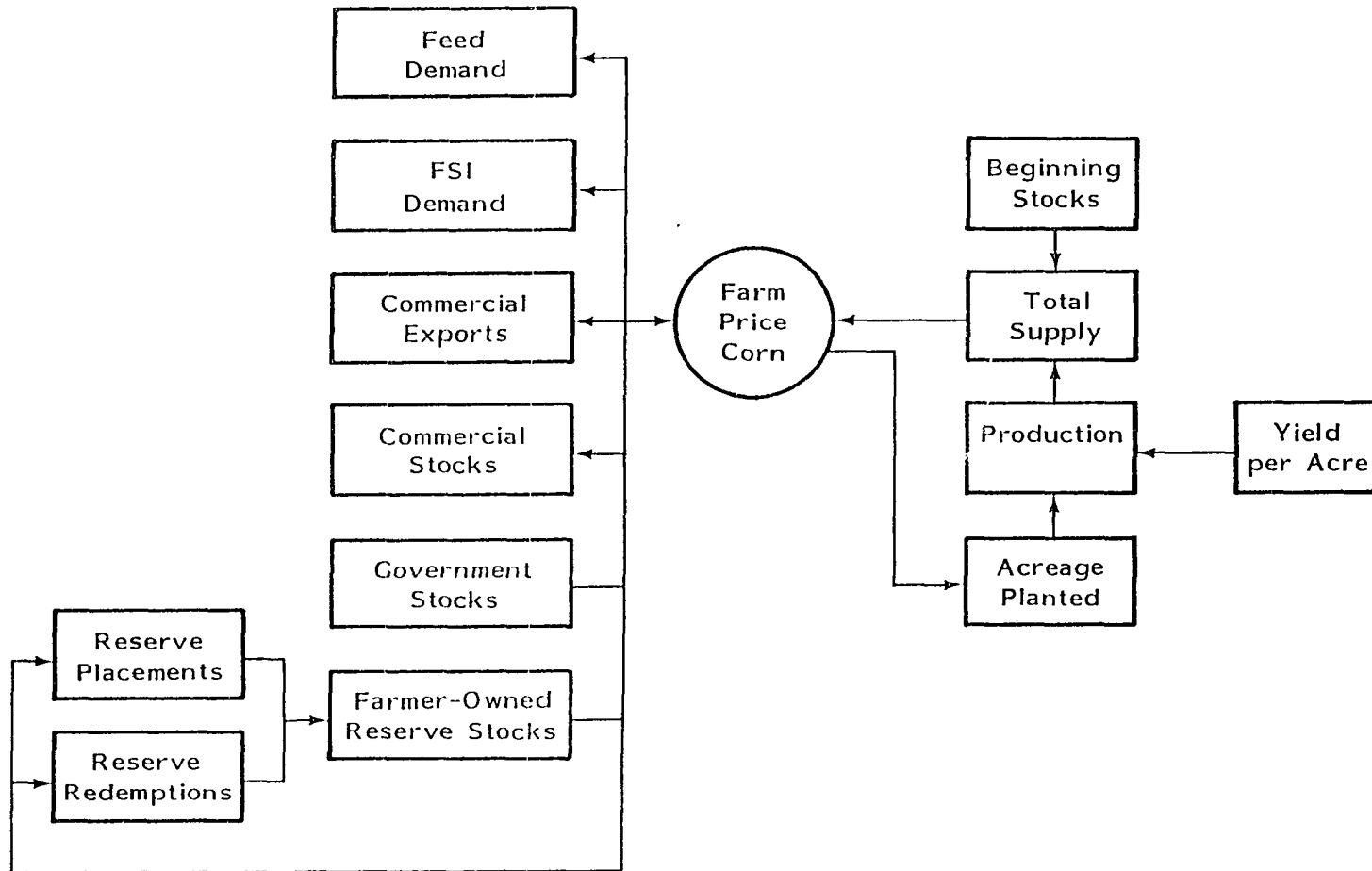industrial, (3) exports, (4) privately-held free stocks, and (5)

Figure 6.1. Schematic illustration of the structure of the corn market of the model

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farmer-owned reserves. The allocating mechanism, the current equilibrium price, is determined by the intersection of the sum of these demand components with the predetermined supply. Ending reserve stocks in the specification are not directly regarded as a stochastic quantity, but rather by identity equal to beginning stocks plus the price-responsive difference between placements into the program and redemptions from the program. Primary demand side interactions in the subsystem are also present between ending reserve stocks of corn and commercial stocks of corn. The only behavioral component of the supply side of the corn market is the planted acreage response by corn producers in the spring quarter. The production of corn entering in the fall quarter is thus predetermined, based on planting decisions two quarters earlier. The primary linkage between the corn sector of the model and the livestock sector is the number of livestock units on grain-based feeds.

The livestock component of the model, illustrated in Figure 6.2, encompasses the consumption and production, and farm and retail prices of the three meat products (fed beef, pork and broilers), and inventory levels of livestock used in the production of these products. The fed beef subsystem of the model is structurally the most complicated of the three livestock markets represented. The behavior of the beef subsystem is crucially dependent on two producer decisions: the number of cows held in the breeding herd, and the number of cattle placed on concentrate feeds. The number of beef cows on hand largely determines the subsequent calf crop, and hence, directly affects feeder calf prices, a key intermediate input in fed beef production. The availability of steers and heifers for placement
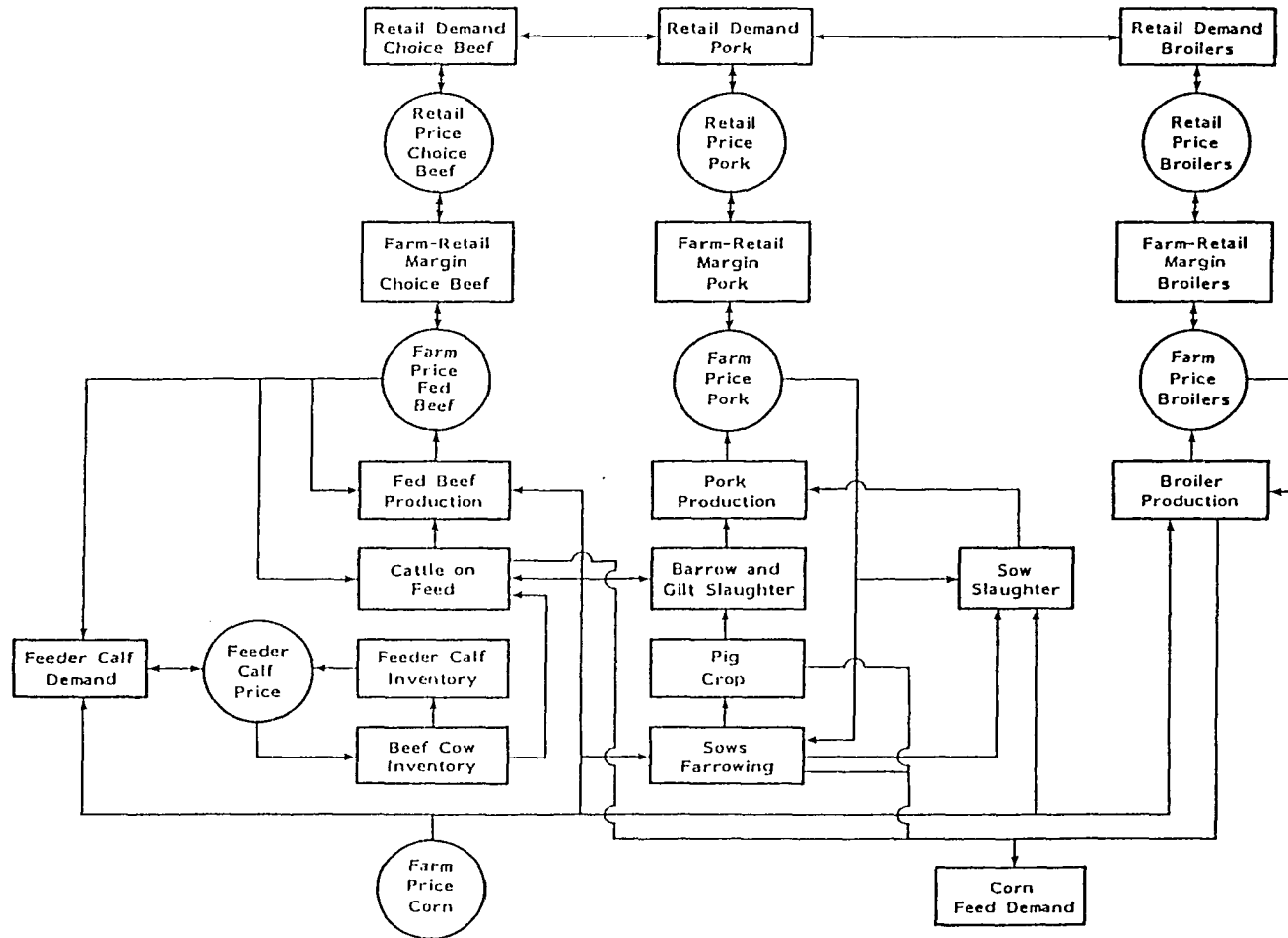
Figure 6.2. Schematic illustration of the livestock sector component of the model and its linkages to the corn market

on feed depends closely on prior calf crops, with an allowance for the
number of calves previously slaughtered. However, since these cattle and
calves may alternatively be raised on pasture, the number of cattle on feed
is also quite responsive to such economic factors as the price of slaughter
steers, and the cost of concentrate feeds. The meat from steers and heifers
on feed comprises around 70 percent of total beef production, and provides
the great majority of beef used for table cuts at the retail level. A
margin equation is present for each of the commodities, and allows for the
transmission of price signals between consumers and producers by linking
prices at the retail and farm level.

The pork sector of the model is somewhat simpler in structure than the
fed beef sector. However, it encompasses two sources of production -- that
from the slaughter of barrows and gilts, and that from the slaughter of sows
from the breeding herd. The production of pork from barrows and gilts is
largely unresponsive to current economic variables, rather governed by
previous pig crops. Thus, the number of sows farrowing in previous periods,
which determine pig crops, define within a narrow range the production or
pork from market hogs. The number of sows to farrow tends to respond
closely to the expected profitability of feeding hogs to market weight. As
feeding margins worsen, sows are culled from the breeding herd, and sold for
slaughter.

The broiler industry is represented by a very simple specification in
the model. Broiler production involves relatively short, but still
significant lags in production. It is related to the production of the
other meat groups through the market for feed, but because of its very

specialized nature, does not compete directly for other production resources.

The respective livestock markets are linked together at both the farm and retail level. At the farm level, the sectors compete directly for feed ingredients, and as mentioned in the case of hog and cattle operations, for other production resources, including labor and capital resources. A strong source of interaction similarly exists between the meat groups at the retail demand level. Previous studies have found significant demand substitutability between meats, and usually a strong relationship between meat demand and consumer incomes. These interdependencies ensure that the prices of the commodities remain closely related.

Estimation procedure

The annual equations of the model and the structural equations not characterized by simultaneous determination, were estimated by ordinary least squares. In this context, the ordinary least squares (OLS) estimates of the structural parameters retain the desirable properties of unbiasedness and efficiency. The remaining equations of the model were estimated by applying two stage least squares to the historical data. Because the number of predetermined variables in these equations was less than the total number of observations, the entire set of predetermined variables was used as first stage regressors in the procedure. Estimates generated by two stage least squares are not asymptotically efficient, as would be a system estimator, but they are preferable to OLS estimates from the standpoint of consistency.

No adjustments were made during estimation of the model for serially correlated errors among the equations, in spite of the fact the some

Durbin-Watson statistics were rather low. When viewing the model as a

linear approximation to a complex nonlinear structure, the choice between

the reported coefficients and those resulting from the ad hoc assumption of

simple serial correlation appeared a somewhat arbitrary matter. Moreover,

adjusting for serially correlated errors in a simultaneous equations model

in the presence of lagged dependent variables significantly compounds

estimation difficulties.

For the most part, the parameters of the model were estimated from

quarterly data for the period 1971IV-1982IV. The beef cow inventory

equation was estimated on an annual basis because of data limitations,

whereas the structural equation for acreage planted depicts an economic

decision occurring only annually. The historical period for estimating

these two equations was somewhat longer than the period used for the

remainder of the model.

Empirical Estimates of the Structural Equations

In the study, numerous specifications and testing of relationships were

conducted before a final structure was formulated. The reported

coefficients for the structural equations are the preferred estimates from

this analysis. Variables were retained in the specification if the

coefficients were of the correct a priori sign, and reasonable magnitude, in

spite of the fact that some had standard errors quite large relative to the

point estimates. For each equation, summary statistics including absolute

t-ratios, R-square, Durbin-Watson (DW) or Durbin-h (DH) statistics (see

Durbin, 1970), and the ratio of the standard error of regression to the

dependent variable mean (S/M) are presented. Elasticities of the dependent

variable with respect to certain explanatory variables are also presented,
together with the estimation procedure and period used for the equation.
The absolute t-ratios are given in parentheses under each estimated
coefficient. The S/M statistic, and more importantly, the R-square
statistic are presented because the two are widely recognized as measures of
statistical fit, although as has been pointed out (e.g., Basmann 1962), the
R-square statistic may be biased in certain applications. Elasticity
measures are similarly recognized and serve as important indicators of the
structure implicit in econometric model. Absolute values of the point
elasticities evaluated at the sample period means, are presented in brackets
under the estimated coefficients of continuous-valued exogenous variables.

Corn Demand

Feed demand   Although declining somewhat in relative importance, the
demand for corn as a livestock feed remains the largest component of total
corn demand. Because corn serves as an input in the production of
livestock, its demand as a feed ingredient is derived from the final demand
for livestock products. As such, the quantity of corn consumed by livestock
is assumed to be closely linked to total grain consuming animal units, and
the expected profitability of livestock feeding.

In general, the current period price responsiveness of feed demand is
relatively minor, given the limited flexibility with which livestock numbers
on feed can be quickly adjusted. Livestock prices and the price of corn
thus, tend to exert the strongest influences on corn demand through lagged
impacts on livestock numbers. However, there is some current period price
response through variations in feeding rates/animal and feed periods. When

feeding margins are favorable, producers frequently respond by increasing

feeding rates and the period on feed, choosing to market slaughter animals

at heavier weights. In this manner, current period prices account for some

of the variation in feeding patterns when the number of livestock on feed is

relatively fixed.

Historically, the strongest feed demand has occurred during the fall

quarter. Over one-third of total corn fed for the year is consumed in the

fall. A marked peak in cattle placements on feed occurs at this time

creating a surge in feed requirements, which declines steadily through the

rest of the marketing year. Because the feed demand for corn tends to be

the most price responsive in the fall, slope dummies were attached to corn

prices to allow for seasonal shifts in the parameters.

Domestic feed consumption of corn is estimated by the following

equation:

$$
\begin{aligned}
\text{QCRNFEED} = \;& 244.03 - 188.12 \text{*RPCRN} - 47.80 \text{*Q4*RPCRN} - 54.23 \text{*Q1*RPCRN} \\
& (0.53) \quad\; (2.64) \qquad\quad (1.39) \qquad\qquad\; (1.16) \\
& \qquad\qquad\; [0.42] \qquad\qquad [0.37] \qquad\qquad [0.49] \\[6pt]
& - 29.34 \text{*Q2*RPCRN} + 0.0194 \text{*GCAU} + 96.55 \text{*RPWHT} + 450.82 \text{*Q4} \\
& \quad (0.64) \qquad\qquad\quad (2.40) \qquad\quad (2.96) \qquad\quad (5.61) \\
& \quad [0.53] \qquad\qquad\quad [0.86] \qquad\quad [0.30] \\[6pt]
& + 272.36 \text{*Q1} + 19.18 \text{*Q2} \\
& \quad (2.54) \qquad\; (0.18)
\end{aligned}
\tag{6.1}
$$

(S/M = 0.08, R-SQUARE = 0.96, DW = 2.05, quarterly-2SLS, 1971IV - 1982IV)

where:

    QCRNFEED = domestic corn feed use, mil. bu.

      RPCRN = average corn price received by farmers, deflated by
                FPI, $/bu.

GCAU = grain consuming animal units, thou.

RPWHT = average wheat price received by farmers, deflated by
FPI, $/bu.

Q_i = 1 in calendar quarter i, -1 in calendar quarter 3,
0 otherwise (i = 1, 2, 4)

FPI = index of prices paid by farmers, all production items,
1977 = 100

Feed demand for corn was found to be more responsive to the current period price than expected. As hypothesized, this response also varies seasonally. Because of the dummy variable scheme utilized in the model, the coefficient on the own-price variable is the average price response for the four quarters. The coefficient on each of the seasonally varying price variables can then be interpreted as the deviation of that quarter's price response from the average.[1] Thus, through the crop year, the quarterly price coefficients are -235.92, -242.35, -217.46, and -56.75. While prior reasoning suggested that the feed demand for corn would be the most price responsive in the fall quarter, the estimation results indicate that feed demand is more sensitive to price movements in the winter and spring quarters. However, as expected the own-price elasticity is relatively small in the summer, when livestock feeding is lightest. A comparison of the feed price elasticities computed here those from other studies is contained in Table 6.1.

---

[1] the t-statistics for the coefficients on the seasonal price parameters thus test the hypothesis that the slope for that particular quarter is significantly different from the average for the crop year.

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Table 6.1 Corn feed demand elasticity comparisions

	Calendar quarter			
Author	1	2	3	4
This study	-0.49	-0.53	-0.23	-0.37
Subotnik and Houck (1979)	-0.22	-0.15	-0.18	-0.24
Butell and Womack (1975)	***[a]	-0.26	-0.31	-0.25[b]
Womack (1976)[c]	-0.42			
Baumes and Meyers (1980)[c]	-0.32			

[a] No current period price variable appeared in the equation.
[b] Equation specification for the quarter was later changed.
[c] Annual models.

The number of animals consuming grain based feeds (GCAU) is an important determinant of the amount of corn fed to livestock each quarter. The grain-consuming animal units variable serves the same function as a population variable would in a consumer demand relation, except for the fact that it is a decision variable to the livestock producer and hence, is determined within the model. Feeding decisions made in the current and previous two quarters determine the number of livestock on feed, which is carried into the demand for corn relation through this variable. The elasticity of feed demand with respect to GCAU is not significantly different from 1.0, as would be anticipated.

The price of wheat was originally inserted in the specification in only the summer quarter, to reflect feed substitution possibilities, but was found to exert a significant effect in all quarters. Prior specifications

of this equation also included current and lagged values for soybean meal

prices, an index of livestock prices, and the ratio of livestock to corn

prices. However, these variables consistently yielded signs contrary to a

priori expectations and were subsequently dropped from the specification.

In the case of soybean meal prices, the negative estimated coefficient,

although incorrect theoretically, has been found in previous studies, and

was retained in a feed demand equation estimated by Hull and Westcott

(1984).

Food, seed and industrial demand   An increasingly important source

of domestic corn disappearance is accounted for by food, seed, and

industrial (FSI) uses. FSI demand increased steadily from 9 percent of

domestic corn disappearance in 1970, to over 17 percent in 1982. Upwards of

70 percent of the corn going into FSI channels is used in the manufacture of

wet products -- primarily corn starch, and high fructose and glucose corn

syrup.

Similar to feed demand, corn demand for food and industrial uses is

derived from the retail demand for the end products. The demand for corn

for FSI utilization is estimated on a per capita basis as:

$$
\begin{aligned}
\text{QCRNFSIC} = {}& 1.387 - 0.177 \ast \text{RCPCRN} - 0.00029 \ast \text{RDPIC} + 0.064 \ast \text{RCPWHT} + 0.0094 \ast \text{T} \\
& (4.36) \quad (4.02) \qquad\quad (3.27) \qquad\qquad (2.96) \qquad\qquad (14.11) \\
& \qquad\quad\; [0.34] \qquad\qquad [1.44] \qquad\qquad [0.17] \\[2mm]
& - 0.036 \ast \text{Q4} - 0.036 \ast \text{Q1} + 0.093 \ast \text{Q2} - 0.071 \ast \text{D79} \ast \text{Q4} \\
& \quad (2.97) \qquad (3.03) \qquad (7.77) \qquad (3.39) \\[2mm]
& - 0.131 \ast \text{D79} \ast \text{Q1} - 0.045 \ast \text{D79} \ast \text{Q2} \qquad\qquad\qquad\qquad (6.2) \\
& \quad (5.86) \qquad\qquad (2.08)
\end{aligned}
$$

(S/M = 0.05, R-SQUARE = 0.96, DW = 1.20, quarterly-2SLS, 1971IV - 1982IV)

where:

QCRNFSIC = domestic corn food, seed, and industrial use,
per capita, lbs.

RCPCRN = average corn price received by farmers, deflated
by CBPI, $/bu.

RDPIC = disposable personal income per capita, deflated by
CPI, thou. $

RCPWHT = average wheat price received by farmers, deflated by
CBPI, $/bu.

T = time trend

D79 = 1 after 1979IV, 0 otherwise

CBPI = producer price index, cereal and bakery products,
1967 = 100

CPI = consumer price index, all items, 1967 = 100

Initial attempts to estimate the equation yielded quite poor
statistical fits. With the exception of the time trend, none of the
exogenous variables were significant. An analysis of the residuals revealed
a substantial change in the seasonality of FSI demand on and after 1979, and
attributable in part to the growth of the corn sweetener industry. In view
of the structural break, subsequent specifications of the equation allowed
the seasonal intercept shifters to vary after 1979. This change in the
specification greatly improved the fit and the significance of the remaining
explanatory variables.

As can be seen from the estimation results, FSI demand peaks sharply in
the summer months as the demand for soft drinks, a primary user of high
fructose corn syrup, peaks. FSI demand also tends to be quite income
elastic, with a very strong upward trend. While some studies have used a

business cycle proxy as an explanatory variable, such a specification

resulted in strong intercorrelation of variables, and did not significantly

enhance the performance of the equation.

Export demand   Exports of corn are the most volatile component of

total corn demand. Because of difficulty in statistically explaining the

variation in commercial corn exports over time, many studies have opted in

structural models to treat them as predetermined. However, to the extent

that exports are price responsive, such an approach cannot be justified in

this study where FOR policies directly influence the allocation of corn

stocks to the various market channels.

The volume of corn exported by the U.S. is influenced by several

factors. To a large degree, corn exports reflect livestock industry

conditions and feed grain production in importing countries, as well as

shipments by other exporters. However, given that the ability of importing

countries to buy corn from the U.S. is directly affected by foreign exchange

constraints, and the value of their currency relative to the U.S. dollar,

these factors also play critical roles in determining export levels.

Since exported corn is primarily used as a feed ingredient, the major

importer of corn are countries with developed livestock sectors.

Historically, the nations of the European Community (EC) have been the

largest purchaser of U.S. corn, followed by Japan, the USSR, and Mexico. By

and large, the trade policies of the major importers insulate their internal

consumption prices from the U.S. price (Bredahl, Meyers, and Collins, 1979).

The EC countries utilize a variable levy mechanism to insulate their markets

from the world market. Theoretically, variations in exchange rates affect

internal EC corn prices only indirectly through the substitution of corn

with soybeans, or other livestock feed ingredients not subject to the levy

system. Other European countries, and the USSR break the linkage of

domestic prices with the world market through state trading. Japan and

Taiwan are the only major exceptions to the rule, employing essentially free

trade policies such that their prices directly reflect U.S. prices and

exchange rate changes.

The major competitors in the export market for corn include Argentina,

South Africa, Canada, and Thailand. The exports of these countries vary

substantially from year to year, ranging in total from around 16 percent of

the world corn trade to over 30 percent over the last ten years. About 65

percent of annual competitor exports are shipped in the July-December period

(USDA, 1972). This occurs because the bulk of foreign corn that competes

with the U.S. corn for exports is produced in the Southern Hemisphere, where

the growing seasons are reversed. Research work by Bredahl, Womack, and

Matthews (1978) indicates that the policies of the major exporters, and

historical U.S. export patterns, support the hypothesis that the U.S. is

primarily a residual supplier in the world corn trade.

Because exports to the Soviet Union are primarily governed by long term

agreements are not overly responsive to market conditions, the dependent

variable used in the export demand relation is computed as U.S. total corn

exports net of shipments to the Soviet Union. The final estimated equation

is:

$$QCEXNURS = -1580.93 - 108.19*RXPCRN3 - 0.654*EXPCOMP + 18.74*AUEC9J$$
$$(1.76) \quad (3.11) \quad (1.27) \quad (2.14)$$
$$[0.56] \quad [0.17] \quad [5.48]$$

$$+ \; 0.609*QCEXNURS_{t-4} - 136.37*D781 + 132.66*D8034$$
$$(3.74) \quad (2.81) \quad (2.62)$$

$$+ \; 1.38*Q4 - 21.12*Q1 + 39.64*Q2 \qquad\qquad (6.3)$$
$$(0.08) \quad (0.79) \quad (1.48)$$

(S/M = 0.16, R-SQUARE = 0.76, DW = 1.59, quarterly-2SLS, 1971IV - 1982IV)

where:

    QCEXNURS = U.S. corn exports, all destinations except USSR,
               mil. bu.

    RXPCRN3 = three quarter moving average of RXPCRN, $/bu.

    RXPCRN = average corn price received by farmers deflated by
             U.S. dollars/SDR, $/bu.

    EXPCOMP = total corn exports of major competitors, mil. bu.
              (interpolated to quarterly series)

    AUEC9J = three quarter moving average of animal units in
             EC-9 countries and Japan, thou.

    D781 = 1 in 1978I, 0 otherwise

    D8034 = 1 in 1980III and 1980IV, 0 otherwise

Not surprisingly, the export equation fits the poorest of the corn

demand relations. The deliberate and simplifying omission of variables

reflecting supply-demand relationships for importers and other exporters,

lies behind the relatively weak explanatory power of the equation. Initial

estimations employed the current price of corn deflated by dollars per SDR,

as the price variable in the quation. After some testing, however, it was

felt that exports were also responding to previous quarters' prices and

exchange rates, reflecting the fact that many export bookings take place well in advance of shipment. Consequently, a three quarter moving average of deflated prices was inserted into the equation producing better statistical results.

Competitor exports were employed in the equation as a separate regressor, rather than subtracted from the importer demands in formulating the dependent variable. The latter approach is tantamount to the assumption that the U.S. is the residual supplier in the world market, and effectively imposes a coefficient of -1 on total competitor exports in the relation. The approach used here allows for an empirical estimation of the coefficient for competitor exports, and implies a tradeoff of somewhat less than one. Every bushel increase in corn exported by competiting countries was found to displace about two-thirds of a bushel of U.S. corn exports.

To reflect foreign corn demand for livestock feeds, the number of animal units in the nine EC countries and Japan appears as a shift variable in the equation. The elasticity of corn exports with respect to this variable is quite large, and suggests a close relationship between the livestock economies of these countries and the U.S. corn shipments. The four quarter lagged dependent term was introduced into the equation to explain the seasonal variation in export shipments. Two dummy variables also appear to account for the large unexplained variation in exports during specified periods in 1978 and 1980. Earlier regression tests indicated that these two periods were exerting an undue influence on the estimated parameters of the equation.

Commercial inventory demand   Commercial inventories, or free stocks

of corn can be usefully broken down into two categories according to

intention of use. These are pipeline (also called working) stocks and

speculative stocks.

Pipeline stocks are held for convenience reasons and tend to be

unresponsive to prices and price expectations. These stocks are used in the

normal business of feeding, or processing, and have a "convenience yield"

attributable to their being on hand when needed. Pipeline stocks do not

vary much from year to year, and are primarily determined by the volume of

grain handled, as well as the efficiency and size of the transportation

system.

Speculative stocks, on the other hand, can be viewed as an investment

yielding an intertemporal flow of costs and returns. Individuals or firms

with access to storage facilities hold such stocks hoping to profit on

future price increases. Speculative stocks are very sensitive to current

and expected prices and vary sometimes considerably both within and between

crop years. Whereas pipeline stocks are often hedged and decrease risk to

the owner, speculative stocks are normally unhedged and increase the risk of

ownership. Because most of the variation in free stocks is the result of

variation in speculative holdings, attention is focused on explaining this

component when modeling the demand for free stocks.

Original specifications of the stocks equation utilized a partial

adjustment approach based on the flexible accelerator model described in

Womack (1976). Such a specification when estimated, however, resulted in a

very price inelastic relation that contributed substantially to market

instability in historical simulations of the model. In an effort to rectify the situation and restore some of the price response in the equation, the partial adjustment approach was dropped. The final form of the equation is loosely based on the Womack specification, with allowances for the interaction of commercial stocks with FOR stock of corn. The estimated form is:

$$
\begin{aligned}
\text{ICRN} = 3932.46 &- 588.20*\text{RPCRN} + 274.93*\text{Q4}*\text{RPCRN} - 285.76*\text{Q1}*\text{RPCRN} \\
& \quad (4.99) \quad\quad (6.87) \quad\quad\quad (1.69) \quad\quad\quad\quad (2.05) \\
& \quad\quad\quad\quad [0.49] \quad\quad\quad\quad [0.13] \quad\quad\quad\quad [0.61]
\end{aligned}
$$

ICRN = 3932.46 − 588.20*RPCRN + 274.93*Q4*RPCRN − 285.76*Q1*RPCRN
   (4.99) (6.87)   (1.69)   (2.05)
       [0.49]   [0.13]   [0.61]

   − 266.07*Q2*RPCRN + 0.629*D4*XCRN − 0.354*FORSTK − 20.54*D23*APCRN
    (1.77)   (4.93)   (3.59)   (1.23)
    [1.10]   [0.81]   [0.09]   [1.38]

   + 105.32*DPRELS − 2146.47*Q4 + 1443.48*Q1 + 1515.63*Q2   (6.4)
    (1.12)   (1.75)   (1.63)   (1.67)

(S/M = 0.07, R-SQUARE = 0.99, DW = 1.03, quarterly-2SLS, 1971IV − 1982IV)

where:
   ICRN = ending commercial stocks of corn, mil. bu.

   XCRN = total corn production, mil. bu.

  FORSTK = total ending reserve stocks of corn, mil. bu.

   APCRN = total area planted to corn, mil. acres

    D23 = 1 in calendar quarters 2 and 3, 0 otherwise

    D4 = 1 in calendar quarter 4, 0 otherwise

  DPRELS = shifter for periods in which reserve release price
      was adjusted

A strong determinant of the quantity of corn held in storage is the current period price. The current price of corn constitutes an opportunity

cost of carrying corn forward. As price increases, the storage speculator would be expected to market more grain and carry less forward in anticipation of higher prices. Conversely, low prices encourage stockholding, as speculators hope for higher future prices. The specification employed in the equation allows the price responsiveness of commercial stocks to vary between quarters within the marketing year. The results suggest that commercial stocks of corn are relatively price elastic, with the elasticity increasing through the crop year.

Total production of corn appears in the equation in the first quarter of the marketing year only. The coefficient of this variable reflects the marginal propensity to store increased supplies. The estimated relationship implies that a one billion bushel increase in corn production would increase carryout stocks for the fourth quarter by around 630 million bushels. The acreage planted to corn appears in the equation in the spring and summer quarters, and acts as a proxy for late season expected prices. An increase of one million acres in corn planted area in the spring is estimated to draw down free stocks by about twenty million bushels through the summer months.

The two variables FORSTK and DPRELS, depict the influence of the FOR program and its price rules on speculative stockholdings. As demonstrated earlier, the extent of interaction between free and FOR stocks has critical implications for the performance of the FOR program in stabilizing prices. The coefficient of total FOR quantities embodies both the substitution effect and the expectation effect as outlined in Chapter IV, and was hypothesized to fall in the [-1,0] range. The estimated coefficient for reserve stocks in the relation implies that a one bushel increase in

reserves displaces 0.35 bushels of commercial stocks. Implicitly then, around sixty-five percent of the corn entering the program originates from reduced farmer marketings of the commodity. The shift variable for periods of release price adjustment (DPRELS) appears in the equation to capture any effect of a change in the program's price rules on free stocks. Aside from the direct tradeoffs that exist between public stock levels and private stockholdings, Gardner (1982) points out that a public stock program may influence private stockholding behavior through its price rules. For example, an increase in the release price (assuming the reserve is not currently in release status), expands the range over which the market price can freely move, thereby increasing the chance for speculative profits, and thus, the demand for free stocks. The coefficient of DPRELS measures the impact of a change in the reserve's price rules on free stocks, and implies that a one dollar increase in the release price increases free stocks by 105 million bushels.

Farmer-owned reserve demand   In explaining carryover levels of farmer-owned reserves, explicit consideration is focused on modeling not only the demand for corn for placement into the program, but also the demand for redemptions from the program, once trigger prices are reached. These two distinct decisions facing eligible producers are considered separately in this section.

FOR placement behavior   For the eligible producer, the FOR represents a temporary marketing device that can be substituted for a direct sale or speculative storage. As such, the demand for corn for placement into the program is likely to be quite responsive to disparities between the

discounted flow of net returns provided by participation in the reserve program, and the returns to the other marketing alternatives that exist.

A large number of factors influence the returns to FOR participation. Incorporating these factors into a mathematical characterization of the placement decision is one of the major constraints that arises in the analysis of FOR behavior. These factors originate from the provisions of the program (loan rate, interest charge, interest period, storage payment), the producer's situation (cost of capital, storage costs), and the producer's expectations (the sales price at redemption, time of redemption, probability of default). The value of a bushel placed in the reserve includes all these factors and will vary from producer to producer as expectations, the farm's cost of capital and cash storage costs vary.

When evaluating a placement decision, the producer must consider the two possible outcomes of that decision. First, is the possibility that grain placed in the reserve will be released with the producer having the option to redeem the loan. Second is the possibility that grain in the reserve will be turned over to the CCC under the default option, and the loan is not repaid. Clearly, the expected returns to a bushel placed in the reserve will vary depending on the outcome of the loan. If the loan is redeemed prior to or at maturity, the present value (PV_1) of a bushel placed in the reserve in year t is:

$$PV_1 = PL + \frac{P^e_{t+k} - (1 + in)PL}{(1 + r)^k} + \sum_{j=0}^{k-1} \frac{SP_{t+j} - SC_{t+j}}{(1 + r)^j} \tag{6.5}$$

where:

k = number of years to redemption $(0 < k \leq 3)$

PL = loan rate per bushel

P^e_{t+k} = expected sales price at redemption
(release price $\leq P^e_{t+k} \leq$ call price if $k < 3$)

i = CCC interest rate charged on FOR loans

n = number of years interest accrues (assumed $n \leq k$, otherwise $n = k$)

r = the producer's cost of capital

SP = annual storage payment per bushel

SC = annual storage costs per bushel.

If release is never reached through the term of the contract or the producer does not choose to exercise the redemption option, the grain is turned over to the CCC as full loan payment at contract maturity. Under this outcome the present value of a bushel placed in the FOR is simply:

$$PV_2 = PL + \sum_{j=0}^{2} \frac{SP_{t+j} - SC_{t+j}}{(1 + r)^j} \qquad (6.6)$$

In the model, it is assumed that the producer evaluates expected returns to program participation as the maximum of returns to the redemption option, or returns under the default option. The expected returns variable PV, is thus formulated as:

$$PV = \max(PV1, PV2) \qquad (6.7)$$

In addition to the market price, and the returns to participation, the amount of corn that enters the reserve in the current period also responds to the quantity of corn that is eligible for placement, which effectively forms a cap on placements. The amount of eligible corn varies from year to year with total production and the proportion of producers who were in compliance with the current acreage program, if one was in existence. Within the crop year, the quantity of corn available for placement is reduced by marketings, on-farm feeding, and reserve placements in prior periods. As the amount available decreases through the year, the demand for farmer-owned reserves shifts leftward.

Original specifications of the placement equation employed a logistic functional form similar to that suggested by Meyers and Jolly (1980). This specification, however, proved inferior in simulations to the simple arithmetic form used in previous equations, and was subsequently dropped in favor of the linear form. The final placement equation appearing in equation (6.8) was estimated using data only over the period since 1979IV. With the beginning of the 1979 crop, farmers were allowed to bypass the nine month loan program and directly place corn into the reserve program. Prior to that period, the amount of grain maturing from the nine month program defined the quantity of grain eligible for placement, and formed the upper constraint on placements.

The structure by which FOR placements are determined is represented as:

$$PLACE = -1318.75 - 482.68*PCRN + 992.44*PV - 0.0047*AVAIL$$
$$(5.60) \quad (10.28) \quad (11.30) \quad (0.32)$$
$$[5.60] \quad [12.31] \quad [0.07]$$

$$+ 0.027*Q4*AVAIL + 0.049*Q1*AVAIL - 0.049*Q2*AVAIL$$
$$(2.24) \quad (4.38) \quad (4.09)$$
$$[0.29] \quad [0.47] \quad [1.92]$$

$$- 302.14*D823 \tag{6.8}$$
$$(3.60)$$

(S/M = 0.17, R-SQUARE = 0.98, DW = 2.89, quarterly-2SLS, 1979IV - 1982IV)

where:

PLACE = total FOR program corn placements, mil. bu.

PCRN = average price of corn received by farmers, $/bu.

PV = summary variable of expected returns to FOR participation, $/bu. (see computation, p. 255)

AVAIL = total quantity of corn eligible for placement, mil. bu.

D823 = 1 in 1982III, 0 otherwise

Corn placements in the model were initially estimated as varying simply with the price of corn, the expected returns to participation, and the amount of eligible corn. However, in simulation testing the performance of this specification proved less than satisfactory. After examining the residuals, it was felt that placements were responding in a different manner to the amount of grain available as the crop year progressed. Hence, the specification was adjusted in order to allow the coefficient on AVAIL to vary seasonally. This revision yielded the above statistical relationship,

and produced improvements in both the fit of the equation and its simulation performance.

The market price of corn appears in the equation as an opportunity cost of corn placed in the program. As the market price rises relative to the expected returns to participation the producer would be less likely to participate in the reserve, opting instead for the sure returns of the marketplace. An increase in the returns to participation, on the other hand, would shift the function to the right in a price-quantity space, increasing the demand for reserves at a given price. An increase in the demand for reserves would come about if the storage subsidy or the expected sales price at redemption were to increase, whereas increases in the interest charge on the FOR loan, the interest period, the producer's storage costs, and the discount rate would decrease the demand for reserves.

As exemplified by the computed elasticities, program placements tend to be extremely sensitive to both the current market price of corn, and the expected returns to participation. These results are not completely surprising since participation in the FOR involves relatively little risk for farmers, and is a strong substitute with the cash market as a marketing alternative for their grain. In this respect, deviations in the returns to one option over the other would be expected to induce a large quantity response. The large elasticities also suggest that expectations of returns to the FOR option held by farmers are fairly narrowly distributed. If the expected returns were widely distributed across eligible farmers, then logically the elasticity of program placements with respect to PV would be much smaller.

The intercept shift variable D823, was included in the equation to account for the abnormally small placements that took place during the relatively low priced summer of 1982. At this time, the managers of the program extended the rotation period on FOR corn from 30 days before harvest to 60 days, resulting in heavy late season marketings. To a large extent, these marketings displaced new placements into the program.

      <u>FOR redemption behavior</u>   Redemption of FOR grain is not possible until either the market price exceeds the release price, or the FOR contract matures. Once release has been announced a producer may sell or continue to store in hopes of higher returns. Assuming that k periods elapse between the time the producer places grain in the reserve and release occurs, the net returns from immediate sale are:

$$RV_1 = P_t - (1+i_{t-k}n_{t-k})PL_{t-k} \tag{6.9}$$

where:

    P_t is the current market price

    $PR \leq P_t \leq PC$ (call price)

    i_{t-k} is the interest charge per period at the time of placement

    n_{t-k} is the number of periods interest accrues (assumed $n_{t-k} \leq k$, otherwise $n_{t-k} = k$)

    PL_{t-k} is the loan rate per bushel at the time of placement.

The same return would apply if the loan were redeemed at maturity, however, the sales price in this event would not be restricted to the PR, PC range.

If, on the other hand, the producer does not sell the grain in release, but rather continues to store for m more periods anticipating higher prices, he receives (in discounted terms) a net return of:

$$RV_2 = \frac{P^e_{t+m} - (1 + i_{t-k}n_{t-k})PL_{t-k}}{(1 + r)^m} - \sum_{j=0}^{m-1} \frac{SC_{t+j}}{(1 + r)^j} \qquad (6.10)$$

where:

P^e_{t+m} is the expected sales price

$PR \leq P^e_{t+m} \leq PC$

r is the cost of capital per period

SC is the cost of storage per bushel per period.

Assuming m = 1, the representative producer (in the absence of other considerations) could be expected to sell the grain and redeem the loan now if $RV_1 > RV_2$ or, rearranging (6.9) and (6.10), if:

$$P_t > \frac{P^e_{t+1} + r(1 + i_{t-k}n_{t-k})PL_{t-k}}{(1 + r)} - SC_t \qquad (6.11)$$

or,

$$P_t > RV \qquad (6.12)$$

where:

RV is the opportunity cost of immediate cash sale

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The RV expression consists of the discounted value of the sum of the
expected sales price one period later plus an imputed return (negative cost)
of deferring the loan principal and interest payment for one period, minus
the storage cost involved. The redemption function was specified including
the above factors, in addition to lagged reserve stocks, which logically
constrain the amount that may be redeemed in a given period. Only data from
periods of release were used in statistically estimating the parameters of
the redemption function, resulting in only six observations. Although some
redemption of grain does occur at prices below the current release price,
due to contract maturities and grain under previous FOR contracts with lower
release levels, this amount is relatively small.

Equation (6.13) was used to explain corn redemptions from the FOR:

$$REDEMP = 102.07 + 52.12*PCRN - 28.74*RV + 0.0114*FORSTK_{t-1}$$
$$(1.58) \quad (2.11) \quad\quad (0.81) \quad\quad (0.47)$$
$$[0.64] \quad\quad [0.33] \quad\quad [0.03]$$

$$+ 332.30*DCD \tag{6.13}$$
$$(35.56)$$

(S/M = 0.03, R-SQUARE = 0.99, quarterly-2SLS, 1979III - 1982IV:
redemption periods)

where:

REDEMP = total FOR program corn redemptions, mil. bu.

RV = opportunity cost of current marketing in release, $/bu.
(see computation, p. 258)

DCD = 1 in 1981II, 0 otherwise

Given the limited number of observations, the statistics are by no means robust estimates, but do provide a rough measure of the process generating redemptions from the program. The price variables have the expected signs, but do not exert the influence on FOR grain movements, as did those of the placement equation. A large proportion of the variation in the equation is explained by the shift variable, D812. An unprecedented amount of grain came out of the reserve in the spring of 1981, most of which was placed in the program during the previous quarter under the interest-free loan provisions that were shortly thereafter dropped. As the equation was not equipped to account for the unexpected redemptions during the period, the shift variable was included in the specification.

Corn production

The production of corn is predetermined and forthcoming only in the first quarter of the crop year, based on production decisions two quarters earlier. In the model, corn yields per acre are assumed exogenous, such that the production of corn in the first quarter is equal to the product of the yield per acre and the acreage planted the previous spring.

Acreage planted to corn   The planted acreage response by farmers reflects the demand for land as an input in the production of corn. Because corn and soybeans are grown in the same geographical areas and compete closely for land, the acreage planted to corn tends to respond to expected corn and soybean prices, and government policy variables reflecting current acreage programs for the two crops.

The acreage response equation utilized in the model was specified as a partial adjustment process whereby desired plantings are determined by

current corn and soybean prices, diversion payments for corn, and price

support levels for corn. The final estimated relationship is:

$$\text{APCRN} = 46.27 + 11.01*[\text{PCRNA/PSBA}] + 5.53*\text{RPSCRN} - 24.22*\text{RDPCRN}$$
$$\phantom{\text{APCRN} =} (5.99) \quad (1.68) \quad\quad\quad\quad (2.40) \quad\quad (7.73)$$
$$\phantom{\text{APCRN} =} [0.05] \quad\quad\quad\quad [0.11] \quad\quad [0.05]$$

$$+ \; 0.277*\text{APCRN}_{t-4} \quad\quad\quad\quad\quad\quad\quad\quad\quad\quad (6.14)$$
$$ (2.99)$$

(S/M = 0.02, R-SQUARE = 0.96, DH = 0.31, annual-OLS, 1966 - 1982)

where:

APCRN = total area planted to corn, mil. acres

PCRNA = four quarter moving average of PCRN

PCRN = average corn price received by farmers, $/bu.

PSBA = four quarter moving average of PSB

PSB = average soybean price received by farmers, $/bu.

RPSCRN = effective support rate for corn, deflated by FPI, $/bu.

RDPCRN = effective diversion payment for corn, deflated by FPI, $/bu.

Annual data extending from 1966 to 1982 was used in estimating the

parameters of the equation. The data period was chosen to begin in 1966

because of changes in farm program provisions where, from that time on,

price supports (via nonrecourse loans) were only offered to those producers

complying with the provisions of the current acreage program, if in

existence.

Initial estimations of the equation employed the spring quarter prices

of corn and soybeans as separate regressors in the relationship. However,

inclusion of the variables in this form consistently yielded poor
statistical results, and was dropped in favor of a specification using the
ratio of current and lagged corn and soybean prices. Although not
statistically significant at ten percent, the estimated coefficient for the
variable is theoretically plausible. The other two explanatory variables,
RPSCRN and RDPCRN, are policy variables included in the relationship to
explain variations in planted acreage as a result of government backed
incentives or disincentives to plant corn. Both variables are weighted by
restrictions imposed on the programs' participants, using a method similar
to that described in Houck et al. (1976). Diversion payments offered to
eligible producers are essentially government sponsored "rental" rates to
divert land from corn production, and were found in the relation to possess
a great deal of explanatory power for those periods in which such a program
was in existence. The price support, or loan level also exerts a
noticeable, but positive effect on corn acreage response. In addition to
the price support for corn, consideration was given to including the soybean
suport level in the specification. However, given that the support level
for soybeans has historically remained well below the cash price, it is
doubtful to have exerted a systematic affect on corn plantings, and hence
was excluded from the specification.

Livestock and broiler production

Unlike the discrete production and storable characteristics of crop
commodities, meat production is continuous and perishable. Within a three
month period, the quantity of meat can neither be increased or decreased
significantly, leaving price to bear the burden of adjusting the quantity

demanded to the quantity supplied. Because production is essentially predetermined in the short run, the supply of livestock and poultry exhibit very little response to current economic variables, varying instead with production decisions in earlier periods.

Modeling livestock supply response is particularly difficult not only because of the above factors, but also because live cattle and hogs are both a capital input into subsequent meat production, and an immediate source of output. Furthermore, certain livestock classes are hypothesized to exhibit negative supply responses (Reutlinger, 1966), given that an increase in future meat production can only come about by retaining potential slaughter animals for use in the breeding herd. These factors have profound impacts on the dynamic behavior of the system as a whole, and hence, on the specification of a mathematical model of the subsector.

The equations of the livestock model explain the quarterly production of fed beef, pork, and broilers, and the inventories of beef cows, cattle on feed, and sows farrowing.

Beef cow inventories   The number of beef cows on farms and ranches is the fundamental barometer of the cattle inventory cycle. The size of the beef cow inventory largely determines the size of subsequent calf crops, and so exerts a major influence on subsequent beef production.

Beef cows are maintained on farms as an investment in the production of feeder calves. In principle, the desired size of the beef cow herd should respond to the expected discounted returns from producing and selling feeder calves minus the revenue from the current sale of the cows for slaughter.

Since future feeder calf prices are not observable, logically expectations
may be based on actual or past price data.

In the beef cow inventory relation of the model, expected feeder prices
are proxied by the last four quarter's prices with an arithmetic lag
structure. While there are many eligible lag distributions, this type was
employed because of its simplicity and because Freebairn and Rausser (1975)
in a similar application used an arithmetic lag with satisfactory results.
The current rate of interest appears in the equation as a proxy of the cost
of keeping beef cows on hand. While it may be desirable to incorporate
utility cow prices into the equation, this variable is quite collinear with
other beef prices, and in prior studies was used with little success (e.g.,
Martin, 1983).

The specification employed in the model utilizes a partial adjustment
form in determining January 1 beef cows numbers:

$$
\begin{aligned}
BFCWS = &-3501.6 + 0.889*BFCWS_{t-4} + 163.77*RPFDRSA_{t-4} \\
&\ \ (1.37)\ \ \ \ (16.15) \ \ \ \ \ \ \ \ \ \ \ \ (11.26) \\
&\ [0.21]
\end{aligned}
$$

$$
\begin{aligned}
&- 28.76*INTPR \\
&\ \ (0.77) \\
&\ \ [0.01]
\end{aligned}
\qquad (6.15)
$$

(S/M = 0.01, R-SQUARE = 0.97, DH = 1.21, annual-OLS, 1969-1983)

where:

      BFCWS = beef cows on farms, Jan. 1, thou. hd.

   RPFDRSA = four quarter moving average of RPFDRS

    RPFDRS = average price of Kansas City feeder steers, deflated
               by FPI, $/cwt.

INTPR = four quarter moving average of prime interest rates, %

FPI = index of prices paid by farmers, all production items,
1977 = 100

Feeder calf price   Feeder calves are an intermediate product in the
production of beef, and an important input in the production process. A
well-developed market exists for feeder steers and heifers, and facilitates
the allocation of feeders between placement on feed and retention on
pasture.

Cattle finishers' interests in purchasing feeder calves are directly
linked to the profitability of feeding the calves to market weight. The
demand for feeder calves is thus assumed to respond to expected fed beef
prices, and the price of feed. The supply of feeder calves, on the other
hand, is primarily related to previous calf crops, which in turn reflects
the size of the cow herd.

While it would seem preferable to model the demand and supply of
feeders explicitly in a separate submodel within the system, such an
approach in previous studies (e.g., Reeves, 1979; Arzac and Wilkinson, 1979)
was dropped due to estimation problems, in favor of a partially reduced form
equation for price. The latter approach is employed here, where the partial
reduced form for feeder steer prices appears as:

$$
\begin{aligned}
RPFDRS = \ &15.025 + 0.840*RPFBF + 0.626*RPFBF_{t-1} - 5.460*RPCRN \\
&(0.99) \quad (3.65) \qquad\quad (2.59) \qquad\qquad (3.32) \\
&\qquad\quad\ [0.83] \qquad\quad\ [0.62] \qquad\qquad [0.25] \\[6pt]
&- 0.00062*BFCWS_{t-2} - 0.337*Q4 + 2.091*Q1 + 0.087*Q2 \qquad (6.16) \\
&\ (1.76) \qquad\qquad\ (0.28) \qquad (1.90) \qquad\ (0.07) \\
&\ [0.50]
\end{aligned}
$$

(S/M = 0.08, R-SQUARE = 0.89, DW = 0.54, quarterly-2SLS, 1971IV - 1982IV)

where:

RPFDRS = average price of Kansas City feeder steers, deflated
by FPI, $/cwt.

RPFBF = price of choice slaughter steers, Omaha, deflated
by FPI, $/cwt.

RPCRN = average corn price received by farmers, deflated
by FPI, $/bu.

Expected slaughter cattle prices in the relation are proxied by current and lagged price, with the price of corn reflecting feeding costs. The results suggest that the price of feeder cattle changes $0.84 for every dollar movement in live cattle prices. The two quarter lagged inventory of beef cows arises from the supply side of the subsystem, and reflects the supply of feeder calves, thus exerting a negative impact on feeder prices. A ten percent increase in the lagged number of beef cows is expected to reduce the price of feeder cattle by five percent.

Cattle on feed   Slaughter steer prices and the price of feed impact the beef industry primarily through cattle feeding decisions. Since cattle may be finished on either concentrate feed rations or grass, feedlot placements tend to respond noticeably to variations in feeding margins. Because most cow-calf operators prefer calving in the early spring, feedlot numbers also tend to be quite seasonal, peaking sharply in the fall quarter.

The number of cattle on feed in the model is assumed to depend on expected feeding margins, previous calf crops, and seasonal shift variables.

The structural equation depicting end of the quarter cattle on feed numbers
is:

$$COF = -963.74 + 33.084*[RPFBF - 10.68*[1.705*RPCRN + 0.0023*RPSBM]]$$
$$\quad (0.46) \quad (3.00)$$
$$\qquad\qquad\qquad [0.17] \qquad\qquad [0.14] \qquad [0.01]$$

$$+ 0.772*COF_{t-1} + 0.0818*NETCLF + 1287.82*Q4 - 655.67*Q1$$
$$\quad (9.42) \qquad\quad (1.50) \qquad\qquad (9.65) \qquad (4.25)$$
$$\qquad\qquad\qquad [0.31]$$

$$- 465.80*Q2 \qquad\qquad\qquad\qquad\qquad\qquad (6.17)$$
$$\quad (3.47)$$

(S/M = 0.05, R-SQUARE = 0.85, DW = 2.24, quarterly-2SLS, 1971IV - 1982IV)

where:

COF = cattle on feed, 13 states, end of period, thou. hd.

RPSBM = soybean meal price, 44% Decatur, deflated by FPI, $/ton

NETCLF = number of calves on farms proxy, thou. hd.

The bracketed term in the first line of the equation is a cattle
finishing profitability index, defined as the net returns over feed costs of
producing 100 pounds of beef. The index is equal to the live cattle price
per cwt. minus a feed conversion ratio times the cost of 100 pounds of an
eleven percent corn-soybean meal feed ration. The results suggest that a
ten percent increase in the price of live cattle would increase the number
of cattle on feed by 1.7 percent, whereas a ten percent increase in the
price of corn would decrease the number of cattle on feed by 1.4 percent.
The variable NETCLF, is a proxy for the number of calves available for
placement on feed, and is computed as a two quarter lagged number of beef

cows minus total commercial slaughter of calves during the previous two quarters. While it would be desirable to impose calving ratios on total cow numbers, such data is not available on a seasonal basis.

The lagged dependent term was included in the equation as an indicator of delays in adjusting feedlot numbers due to technical constraints. The seasonality of cattle numbers on feed can be seen by investigating the coefficients on the quarterly intercept shifters. At given prices, cattle on feed numbers for the thirteen states tend to be around 1.3 million head higher in the fall quarter than for the rest of the year.

Production of fed beef   The primary factor determining the amount of fed steer and heifer beef produced in a given quarter is cattle placement decisions in previous quarters. Although cattle on feed display a strong degree of seasonality, fed beef marketings, and hence, fed beef production tend to be fairly evenly distributed through the year.

While the number of cattle marketed exhibits very little response to economic factors, there is some current period price response of slaughter weights. Typically slaughter weights are lower than normal in times of poor feeding margins, and heavier than normal when margins are profitable. To account for some of the variation in total beef production by carcass weight when the number of cattle slaughtered is fixed, the cattle finishing profitability index defined above is also included in the beef production equation.

Production of fed beef in the model is explained by the following equation:

$$XFBF = 2389.43 + 0.178*COF_{t-1} + 6.078*[RPFBF - 10.68*[1.705*RPCRN$$
$$\qquad (8.90) \quad (6.24) \qquad (3.06)$$
$$\qquad\qquad\qquad [0.42] \qquad\qquad\qquad [0.07] \qquad\qquad\qquad [0.06]$$

$$+ 0.0023*RPSBM]] - 440.34*D7323 - 569.49*D7534 + 46.07*Q4$$
$$\qquad\qquad\qquad\qquad (3.58) \qquad\qquad (5.24) \qquad\qquad (1.20)$$
$$\qquad [0.01]$$

$$- 4.41*Q1 - 76.91*Q2 \qquad\qquad\qquad\qquad\qquad\qquad (6.18)$$
$$(0.09) \quad (1.96)$$

(S/M = 0.03, R-SQUARE = 0.82, DW = 1.96, quarterly-2SLS, 1971IV - 1982IV)

where:

XFBF = fed steer and heifer beef production, carcass wt., mil. lbs.

D7323 = 1 in 1973II - 1973III, 0 otherwise

D7534 = 1 in 1975III - 1975IV, 0 otherwise

The estimation results evidence the strong relationship between fed beef production and the lagged number of cattle on feed. The coefficient implies an elasticity of 0.42, which seems quite plausible, since the average time for cattle on feed in commercial and farm feedlots is around 190 days, or just over two quarters (Gee et al., 1979). A significant, but minor response of beef production to feeding margins was also detected in the estimation. The shift variable D7323 was included in the specification to explain the displacement of the market from its equilibrium that occurred

during the period of beef price controls from March 29, 1973 to September 10, 1973. Another shift variable appears in the relationship to account for the extremely low production period in 1975. The model in previous simulation tests was consistently overestimating beef production during this period which strongly suggested the omission of a relevant explanatory variable from the specification.

<u>Sows farrowing</u>   The number of hogs slaughtered in the current time period is directly related to the number of sows farrowed some two to three quarters earlier. The decision to farrow is finalized about two quarters before farrowing takes place. Factors influencing the number of sows farrowed include the expected price of hogs at market time, expected feeding and carrying costs, past sow farrowings, and seasonal components. The following equation was used in the model to estimate quarterly farrowings:

$$
\begin{aligned}
SOWF = {} & -276.91 + 8.69*RPPK_{t-2} - 61.45*RPCRN_{t-2} \\
& \;\;(0.70) \quad (2.21) \qquad\quad (1.08) \\
& \qquad\qquad [0.12] \qquad\qquad [0.04] \\[6pt]
& + 0.496*[SOWF_{t-1} + SOWF_{t-2}] - 0.064*Q4*[SOWF_{t-1} + SOWF_{t-2}] \\
& \;\;(10.07) \qquad\qquad\qquad\qquad (8.25) \\[6pt]
& - 0.063*Q1*[SOWF_{t-1} + SOWF_{t-2}] + 0.155*Q2*[SOWF_{t-1} + SOWF_{t-2}] \\
& \;\;(7.78) \qquad\qquad\qquad\qquad\quad (16.99) \\[6pt]
& + 234.23*D7783*Q4 + 62.75*D7783*Q1 - 497.58*D7783*Q2 \\
& \;\;(3.68) \qquad\qquad\;\; (0.95) \qquad\qquad (7.53) \\[6pt]
& - 28.23*INTPR + 9.87*T \qquad\qquad\qquad\qquad\qquad (6.19) \\
& \;\;(2.04) \qquad\quad (1.86)
\end{aligned}
$$

(S/M = 0.04, R-SQUARE = 0.94, DH = 0.67, quarterly-OLS, 1971IV -1983I)

where:

SOWF = number of sows farrowing, U.S., thou. hd.

RPPK = barrow and gilt price, 7 markets, deflated by FPI, $/cwt.

RPCRN = average corn price received by farmers, deflated
by FPI, $/bu.

INTPR = four quarter moving average of prime interest rates, %

T = time trend

D7783 = 1 in 1977I - 1983I, 0 otherwise

It is assumed that expectations regarding future hog and corn prices are determined on the basis of past and present price experiences. Hence, corn and hog prices in period t-2, when the decision to farrow is culminated, are included in the specification. Sow farrowings in the equation respond the most however, to lagged farrowings. The coefficient on the one and two quarter lagged dependent term is quite significant as are the slope shift coefficients on the variable, pointing out some of the seasonality in sow farrowings. Farrowings peak in the March - May period, and according to the equation, also tend to be much more responsive to past farrowings during this period. This result suggests that more gilts are retained for breeding purposes, and more sows culled from the breeding herd after spring farrowing than at other times of the year.

Because of the more intensive use of central farrowing and confinement facilities in hog production, the seasonality in farrowings appears to be diminishing. Hurt and Garcia (1982), for example, note a structural change in farrowing seasonality, and adjust their model specifications accordingly. An analysis of residuals from earlier regressions of the equation in this

study similarly indicated a problem, and revealed a consistent
overprediction of spring farrowings, and underprediction of fall farrowings
in the latter part of the sample period. For this reason, intercept
shifters were introduced, to allow the seasonality of farrowings of change
after 1977. As expected, the results do indicate a significant decrease in
the number of sows farrowing in the spring in latter years, and a
corresponding increase in fall farrowings. The specification also includes
interest rates to reflect the costs of maintaining sows in the herd, and a
time trend. Attempts to include cattle prices in the equation, as a proxy
of returns to alternative uses of farm resources, and pigs saved per litter
produced inconsistent estimates, and failed to improve the performance of
the equation.

Barrow and gilt slaughter   The magnitude of barrow and gilt
slaughter for the entire swine industry is determined within fairly narrow
limits once farrowings have taken place. Since six months is the average
time required for a pig to reach market weight, two or three quarter lagged
pig crops (computed in the model as sow farrowings times pigs saved per
litter) are the two primary variables in the specification. To detect any
seasonal patterns in gilt retention for breeding purposes, the coefficient
for lagged pig crops is allowed to vary by quarter. The final version of
the equation is:

$$BGSLT = 2673.28 + 0.646*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$\quad (1.76) \quad (12.18)$$
$$\quad\quad\quad\quad [0.79]$$

$$- 0.014*Q4*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$(1.57)$$
$$[0.8]$$

$$- 0.017*Q1*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$(2.09)$$
$$[0.80]$$

$$+ 0.014*Q2*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$(1.72)$$
$$[0.79]$$

$$+ 42.70*T - 128.85*RPCRN_{t-1} - 1647.31*D7323 \quad\quad\quad (6.20)$$
$$(4.70) \quad (0.56) \quad\quad\quad (2.18)$$

(S/M = 0.04, R-SQUARE = 0.91, DW = 1.65, quarterly-OLS, 1971IV -1983I)

where:

BGSLT = slaughter of barrows and gilts under federal inspection, U.S., thou. hd.

PIGCRP = pig crop, U.S., thou. hd.

D7323 = 1 in 1973II, 1973III, 0 otherwise

Since the impact of past pig crops was allowed in the specification to vary seasonally, for ease of interpretation the two and three period lagged terms were combined into a weighted term. From initial tests, it was estimated that close to 75 percent of the market hogs slaughtered in a given quarter were farrowed two quarters earlier, and 25 percent, three quarters earlier. These two proportions were subsequently imposed on lagged pig crops in computing the weighted term. As expected this variable explains a substantial proportion of variation in the number of barrows and gilt

slaughtered. The elasticity of barrow and gilt slaughter with respect to lagged pig crops is 0.80. The slope shifters on the term, furthermore indicate that hog producers tend to retain more gilts for breeding purposes from spring and summer farrowings than other times of the year. This finding directly supports the empirical results reached in the sows farrowing equation in (6.19) above.

The slaughter of barrows and gilts also displays a strong upward trend, and responds in part to lagged corn prices. A dummy variable for the price control period in 1973 illustrates the constrained disequilibrium situation that resulted as production in the major livestock markets was displaced from a state of equality with demand.

Sow slaughter   The number of sows marketed for slaughter is contingent upon past farrowings and expectations of the future profitability of raising hogs. As expected returns to raising market hogs increase, breeding herds are built up, and fewer sows are sold for slaughter. The following equation estimates sow slaughter:

$$
\begin{aligned}
\text{SOWSLT} = & -267.07 - 6.35 * \text{RPPK}_{t-1} + 132.33 * \text{RPCRN}_{t-1} \\
& \;\;(0.93) \quad (2.71) \qquad\quad (4.39) \\
& \qquad\qquad\;\; [0.24] \qquad\qquad [0.26] \\[6pt]
& + 0.213 * [\text{SOWF}_{t-1} + \text{SOWF}_{t-2}] + 0.007 * \text{Q4} * [\text{SOWF}_{t-1} + \text{SOWF}_{t-2}] \\
& \;\;(6.26) \qquad\qquad\qquad\qquad\;\; (1.46) \\
& \;\;[1.20] \qquad\qquad\qquad\qquad\;\; [1.19] \\[6pt]
& - 0.017 * \text{Q1} * [\text{SOWF}_{t-1} + \text{SOWF}_{t-2}] - 0.003 * \text{Q2} * [\text{SOWF}_{t-1} + \text{SOWF}_{t-2}] \\
& \;\;(4.04) \qquad\qquad\qquad\qquad\;\; (0.55) \\
& \;\;[1.24] \qquad\qquad\qquad\qquad\;\; [1.24] \qquad\qquad\qquad (6.21)
\end{aligned}
$$

(S/M = 0.09, R-SQUARE = 0.81, DW = 1.23, quarterly-OLS, 1971IV - 1983I)

where:

SOWSLT = slaughter of sows under federal inspection, U.S., thou. hd.

One quarter lagged corn and hog prices indicate the desireability of either selling or re-breeding sows. At the means, the results indicate that a ten percent increase in the price of corn, or decrease in the price of market hogs, would increase the slaughter of sows by around 2.5 percent, reflecting the diminished profit potential from raising hogs. The estimation also suggests that a larger percentage of sows in the breeding herd are culled in the summer and fall months, and marketed for slaughter.

Pork production   Because of the absence of data on the number of hogs not slaughtered under federal inspection, the production of pork is stochastically represented in the model rather than calculated by identity. Meat from the slaughter of barrows and gilts comprises the great majority of that used in the production of pork. Through the sample period, the slaughter of barrows and gilts accounted for around 94 percent of the total slaughter mix, while the slaughter of sows represented five percent. In general, pork production exhibits very little response to current period prices.

The production of pork is represented by equation (6.22):

$$XPK = -95.02 + 0.186*BGSLT + 0.224*SOWSLT + 23.46*Q4 -14.02*Q1$$
$$(1.76) \quad (36.98) \qquad (4.87) \qquad\qquad (2.36) \qquad (1.23)$$
$$\qquad\qquad [0.97] \qquad\qquad [0.07]$$

$$+ 16.15*Q2 - 1.46*T \qquad\qquad (6.22)$$
$$(1.51) \qquad (2.65)$$

(S/M = 0.01, R-SQUARE = 0.99, DW = 0.78, quarterly-2SLS, 1971IV - 1983I)

where:

XPK = commercial production of pork, carc. wt., mil. lbs.

The coefficients on slaughter numbers in the equation are highly significant but cannot be strictly interpreted as dress weights per head, due to the fact that some slaughter classes were excluded from the specification. The elasticity on barrow and gilt slaughter is very close to one, as would be expected. The negative sign on the trend variable represents continuation of the tendency toward the marketing of leaner "meat-type" hogs.

Broiler production   The production of broiler meat is largely determined by the broiler hatch in the previous quarter, which in turn reflects production intentions based on future price expectations. Allowing current farm broiler prices and corn prices to proxy future expectations, and given the one quarter lag in production, the equation is specified as:

$$XBRL = -62.84 + 9.48*RPBRL_{t-1} - 31.15*RPCRN_{t-1} + 2.55*LPROD$$
$$(0.27 \quad (2.80) \quad (1.66) \quad (2.06)$$
$$[0.09] \quad [0.03] \quad [0.12]$$

$$+ 0.854*XBRL_{t-1} - 179.19*Q4 + 20.29*Q1 + 182.71*Q2 \qquad (6.23)$$
$$(7.08) \quad (9.93) \quad (1.00) \quad (11.05)$$

(S/M = 0.02, R-SQUARE = 0.99, DH = 0.03, quarterly-OLS, 1971IV - 1983I)

where:

       XBRL = total production of broiler meat, RTC wt., mil. lbs.

      RPBRL = farm price of broilers, deflated by FPI, ¢/lb.

      LPROD = index of labor productivity in poultry production, interpolated to quarterly series, 1977 = 100

The desired production of broiler meat was found to respond closely to lagged prices, and an index of labor productivity in the poultry sector. The latter variable was included in the specification to account for the increasingly capital intensive processes used in poultry feeding. The production of broiler meat is also quite seasonal, peaking in the second quarter of the year.

Retail meat demand

The specifications used in the retail demand equations for the three meat commodities are based upon the neoclassical theory of utility maximization. Although no reference is made to a specific utility function, it is assumed that the function is separable between meats and other commodities. As such, the quantity demanded for each meat by the representative consumer may be characterized as a function of the prices for each of the three meats, a price index for other products, and disposable income.

For simplicity in the aggregation of individual demand relations into a market demand function, identical consumer preferences are assumed. In this framework then, the dependent variable may be represented in a per capita form. Although such a specification restricts the elasticity of demand with

respect to population to one, it does avoid the multicollinearity problems that frequently exist between population and disposable income, and decreases the number of estimable parameters.

Under the postulate that consumer demands are homogeneous of degree zero in all prices and income, the number of variables, and hence parameters in each demand equation may be further reduced by designating the price of all other goods as the numeraire, and deflating the remaining prices and income by this variable.

The final versions of the retail demand equations for each of the three meat commodities are:

QTBFC = 11.71 − 0.196*RPRCF + 0.128*RPRGBF + 0.022*RPRPK − 0.009*RPRBRL
          (3.81) (5.95)   (3.53)   (1.34)   (0.21)
                  [1.15]   [0.45]   [0.10]   [0.02]   .

        + 0.0054*RDPIC − 1.697*D7323 − 0.095*T − 0.215*Q4
          (5.36)   (3.36)   (7.07)   (1.75)
          [1.10]

        − 0.118*Q1 + 0.021*Q2   (6.24)
          (0.99)   (0.17)

(S/M = 0.03, R-SQUARE = 0.87, DW = 1.41, quarterly-2SLS, 1971IV − 1983I)

QPKC = 23.95 + 0.011*RPRCBF + 0.093*RPRGBF − 0.165*RPRPK − 0.008*RPRBL
         (11.64) (0.55)   (4.09)   (15.39)   (0.34)
                 [0.06]   [0.32]   [0.71]   [0.02]

       − 0.0003*RDPIC − 0.042*T + 0.875*Q4 − 0.016*Q1 − 0.454*Q2 (6.25)
         (0.42)   (5.17)   (9.75)   (0.19)   (5.05)
         [0.06]

(S/M = 0.02, R-SQUARE = 0.97, DW = 1.26, quarterly-2SLS, 1971IV − 1983I)

QBRLC = 4.679 - 0.016*RPRCBF + 0.071*RPRGBF + 0.020*RPRPK - 0.129*RPRBRL
        (2.65) (0.96)   (3.54)   (1.64)   (4.26)
                [0.14]   [0.37]   [0.13]   [0.41]

        + 0.0013*RDPIC + 0.061*T - 0.619*Q4 - 0.348*Q1 + 0.471*Q2   (6.26)
          (2.05)   (8.04)   (7.52)   (4.81)   (6.15)
          [0.40]

(S/M = 0.02, R-SQUARE = 0.96, DW = 1.32, quarterly-2SLS, 1971IV - 1983I)

where:

   QTBFC = consumption of fed beef per capita, lbs.

   QPKC = consumption of pork per capita, lbs.

   QBRLC = consumption of broiler meat per capita, lbs.

   RPRCBF = retail price of choice beef, deflated by CPI, ¢/lb.

   RPRGBF = retail price of ground beef, deflated by CPI, ¢/lb.

   RPRPK = retail price of pork, deflated by CPI, ¢/lb.

   RPRBRL = retail price of frying chicken, RTC, deflated by CPI,
            ¢/lb.

   RDPIC = disposable personal income per capita, deflated by CPI,
           thou. $

   T = time trend

   D7323 = price control dummy, 1 in 1973II - 1973III, 0 otherwise

The retail demand for all three meat groups exhibit very strong
own-price responses. In the case of choice beef, this response tends to be
quite elastic. A strong degree of substitution between consumption of the
meat commodities and consumption of ground beef is also revealed in the
relations. Some of the other estimated cross-price effects, however, enter
with a negative sign, contrary to a priori expectations. Although each is

statistically insignificant, such results have been encountered in previous demand system studies, and were explained by Hayenga and Hacklander (1970), as evidence of consumers' desire for a "variety" in their diet. These findings only occur in the model between the consumption of broiler meat, and that of the other two meat groups.

The coefficients on the time variables in the relations point out the strong trends developing in the consumption of red meats and poultry. Both choice beef and pork consumption display a strong downward trend. Per capita consumption of the two meats is decreasing by 0.1 lbs. and 0.04 lbs. per quarter, respectively. Consumption of broiler meat, on the other hand is increasing by 0.06 lbs, per quarter per capita. Moreover, the demands for choice beef and chicken are strongly, and positively related to disposable income, whereas retail pork demand exhibits a weak, negative response to income. The response of choice beef consumption to income variation is quite elastic, as expected. A degree of seasonality is also evident in the demand functions for broiler meat and pork. The freeze on beef prices imposed by the Nixon Administration was estimated to have reduced the per capita consumption of choice beef by almost 1.7 lbs. below desired levels.

For comparison purposes, the retail demand elasticities of this study are presented in Table 6.2, with those computed from other econometric studies similar to this one. The elasticities of choice beef with respect to price and income are quite consistent with those reported in earlier studies. While the computed price elasticity for pork appears reasonable, the implied income elasticity for pork in the model is somewhat disturbing.

Table 6.2. Retail price and income elasticities for different studies

	Own-price elasticity			Income elasticity		
	Choice beef	Pork	Chicken	Choice beef	Pork	Chicken
This study	-1.15	-0.71	-0.41	1.10	-0.06	0.40
Freebairn and Rausser (1975)	-0.83	-0.84	-0.85	1.61	0.46	0.75
Arzac and Wilkinson (1979)	-1.86	-0.87	-0.98	1.02	0.65	0.52
Martin (1983)	-0.71	-0.74	-0.63	1.34	0.62	0.67

The other studies report significant positive impacts of disposable income on the consumption of pork, whereas the findings here, although insignificant statistically, suggest pork to be an inferior good. The contradiction in results may partially be attributable to the specifications employed in the models. This study, opposed to the others, utilized a trend variable in the equation which explained a large proportion of variation in the demand for pork, decreasing quite markedly the significance of the income variable over time. The broiler market responses in the model are somewhat less elastic than those of the other studies, however, in the Freebairn and Rausser, and Arzac and Wilkinson studies, the consumption of chicken includes all classes, not only that of broilers, and must be evaluated accordingly.

Farm-retail price margins

Marketing margins in the model link the farm and retail prices of the respective meat commodities. Farm-retail margins are represented endogenously because of strong interdependencies that exist between price margins and farm commodity prices. To the extent that retail prices are a relatively constant percentage markup of farm prices, a margin equation approach is preferable to a derived-demand approach as formulated by Gardner (1975).

Because of the absence of a suitable deflator, the margin equations are represented in nominal form. The final versions of the equations are:

$$
\begin{aligned}
MFBF = {}& -13.349 + 0.712*PFBF + 1.015*PFBF_{t-1} + 10.039*WHMP \\
& (4.89) \quad (2.78) \qquad\quad (5.08) \qquad\qquad (12.52) \\
& \qquad\qquad\; [0.28] \qquad\quad\; [0.40] \qquad\qquad [0.52]
\end{aligned}
$$

$$
\begin{aligned}
& - 0.788*BPAB - 0.72*Q4 + 2.119*Q1 - 0.160*Q2 \qquad\qquad (6.27) \\
& \;\; (2.70) \qquad\quad (0.63) \quad\;\; (2.12) \qquad (0.13) \\
& \;\; [0.09]
\end{aligned}
$$

(S/M = 0.03, R-SQUARE = 0.99, DW = 1.37, quarterly-2SLS, 1971IV - 1983I)

$$
\begin{aligned}
MPK = {}& -3.858 + 0.198*PPK + 0.842*PPK_{t-1} + 7.753*WHMP \\
& (1.52) \quad (1.60) \qquad\;\; (9.61) \qquad\qquad (21.33) \\
& \qquad\qquad [0.09] \qquad\;\; [0.40] \qquad\qquad [0.59]
\end{aligned}
$$

$$
\begin{aligned}
& - 0.456*BPAP - 0.230*Q4 + 1.269*Q1 - 1.870*Q2 \qquad\qquad (6.28) \\
& \;\; (0.73) \qquad\quad (0.28) \quad\;\; (1.72) \qquad (2.46) \\
& \;\; [0.03]
\end{aligned}
$$

(S/M = 0.03, R-SQUARE = 0.98, DW = 1.51, quarterly-2SLS, 1971IV - 1983I)

$$
\begin{aligned}
\text{MBRL} = &\ 8.862 + 0.522*\text{PBRL} + 0.248*\text{PBRL}_{t-1} + 3.013*\text{WHPD} \\
&\ (7.43)\quad (3.72)\qquad\quad (1.76)\qquad\qquad (10.09) \\
&\qquad\qquad\ \ [0.33]\qquad\quad [0.16]\qquad\qquad [0.28]
\end{aligned}
$$

$$
\begin{aligned}
&+ 0.491*\text{Q4} - 0.035*\text{Q1} - 0.823*\text{Q2} \qquad\qquad\qquad (6.29) \\
&\quad (0.94)\qquad (0.09)\qquad (2.48)
\end{aligned}
$$

(S/M = 0.03, R-SQUARE = 0.95, DW = 1.99, quarterly-2SLS, 1971IV - 1983I)

where:

MFBF = farm-retail price margin for fed beef, ¢/lb.

MPK = farm-retail price margin for pork, ¢/lb.

MBRL = farm-retail price margin for broilers, ¢/lb.

PFBF = choice slaughter steer price, Omaha, $/cwt.

PPK = barrow and gilt price, 7 markets, $/cwt.

PBRL = farm price of broilers, ¢/lb.

WHMP = average hourly earnings for production workers in meat packing, $

WHPD = average hourly earnings for production workers in poultry dressing, $

BPAB = beef by-product allowance (carcass plus farm allowance), ¢/lb.

BPAP = pork by-product allowance, ¢/lb.

The farm price variables in the equations reflect the proportion of marketing costs which may be viewed as a percentage markup. Because there is some evidence of delays in price adjustment between the farm and retail levels (Miller, 1979), lagged prices are also included in the specifications to allow for the possibility of "stickiness" in price adjustments. As indicated by the respective elasticities, the margins for choice beef and

pork do appear to respond slowly to changing farm level prices, whereas the margin for broilers is more strongly related to current prices, suggesting a much quicker response.

Marketing costs in the equations are proxied by wage rates in the meat packing and poultry dressing industries. The cost of labor is the largest component of total marketing costs, accounting for 44 percent of the total food marketing bill in 1982 (Dunham, 1983). These variables possess a great deal of explanatory power in the equations, and appear to be strong determinants of differences between farm and retail prices. The by-products variables were included in the beef and pork equations because of their importance as a source of total packer returns. Variations in the by-product allowances were found to exert negative impacts on margins, indicating that an increase in the value of by-products, for example, would act to decrease the spread between the farm and retail prices of the final products. In the poultry dressing industry, the value of by-products is negligible, and hence, was excluded from the specifications.

Market clearing identities

The supply and demand of the meat commodities are linked through a series of market identities. Most are relatively straightforward, but involve some assumptions.

In the model, fed beef is classified as meat produced from cattle finished on concentrate feed rations, and excludes beef from cull cows, range-fed beef, and imported beef. However, high quality table cuts of meat at the retail level are derived from both ration-fed and range-fed beef. It is assumed that 77 percent of the weight of fed and nonfed beef carcasses

goes into the production of table quality beef. Correspondingly, 23 percent of the carcass weight of these two beef classifications is used in the production of processed beef. Cold storage stocks of beef, and beef from cows, bulls, and imported animals are treated as also being of processing quality. These assumptions follow from that suggested by Ryan (1980), and are consistent with the assumptions used in other studies of the U.S. livestock sector (e.g., Martin, 1983).

For reference, the equations and identities of the entire structural model are represented together in Appendix B.

CHAPTER VII. VALIDATION OF THE ECONOMETRIC MODEL

While simulation and multiplier techniques are valuable tools in applied econometric research, the outcomes generated by these approaches reflect only the properties of the underlying structural model. As a result, the justifiable use of these techniques in a policy analysis or forecasting exercise first requires demonstration that the stuctural model provides an adequate representation of the real world.

The validation of econometric models is one of the most problematic aspects of econometric work. Validating a model is essentially an exercise in hypothesis testing. Yet unlike standard statistical testing of a hypothesis, there are no generally recognized methods of statistical inference available for use in the validation process. Accepting or rejecting a model therefore becomes largely a matter of good judgment. Silberberg (1978) points out that although the validity of a model may be rejected at any stage in the validation process, its validity can never be proved. As a result, the validation process becomes essentially that of subjecting the model to a series of tests designed for different purposes. If the model performs satisfactorily in testing, then gradually the confidence that can be attached to the results of a forecast or policy simulation of the model may be increased.

Several validity measures are adopted in this chapter to test the amount of "realism" built into the corn-livestock model developed in the previous chapter. These measures are generated from historical simulations

of the model, outside the sample (i.e., ex post) model forecasts, and multiplier analysis.

Historical Simulations of the Model

An examination of the ability of the corn-livestock subsector model in tracking key market variables over the sample period provides a good indication of its ability in describing the subsector's dynamics. A historical simulation of the model is conducted in this section to evaluate the performance of the model in replicating observed behavior in the relevant markets over the historical period.

A fully dynamic simulation of the model is one of the most rigorous tests of the model. In a simulation exercise of this type, there is opportunity (through lagged endogenous variables) for single equations' errors to interact with each other as they pass through other equations within the system. Even modest errors in the model could build into progressively larger errors, causing the solution values to diverge more and more from their actual paths. Since the equations of the model are intertemporally dependent in a dynamic simulation it provides a primary means for assessing the model's stability over time.

The model developed in this study resides on a relatively large set of exogenous variables. In the dynamic simulation below the actual time paths of these variables are taken as given, as are the values of the endogenous variables during the initialization procedure. With the exogenous variables conditioning the model, the solution is then evolutionary as lagged simulated values of the endogenous variables replace actual lagged values of these variables in the model's solution.

Because of nonlinearities in the system, the simulation of the model was executed using Newton's nonlinear method in the SIMNLIN procedure of SAS/ETS (SAS, 1980). The equations presented in the previous chapter, together with the identities of the model given in Appendix B, were solved simultaneously for each quarter of the period, 1971IV – 1982IV. The actual and simulated values for selected endogenous variables are plotted over time in Figures 7.1 – 7.16. For reference, summary error statistics generated from the simulation are also presented (Table 7.1). These statistics include the root mean squared percent error (RMSPE), Theil's U – statistic (U), and Theil's inequality proportions.

The root mean squared percent error and Theil U are relative error measures and more meaningful in this context than the standard root mean squared error statistic. For each of the endogenous variables, the RMSPE statistic reflects the percentage deviation of the simulated values of the variables from their historical paths. The Theil U statistic is related to but not the same as the RMSPE statistic. If the predictions of a variable exactly coincide with the actual historical values, then the U – statistic, equals zero, as does RMSPE. If the model forecasts no better than a "naive" model of no change from the previous period, then U = 1. If U > 1, the predictive power of the model is inferior to a naive forecast.

Theil's inequality proportions are composed of three components. These components are the bias proportion U_B, the regression error proportion U_R, and the disturbance proportion U_D, which together sum to one. The bias proportion reflects any difference between the mean of the simulated values for a variable from the mean of the actual values of the variable. The
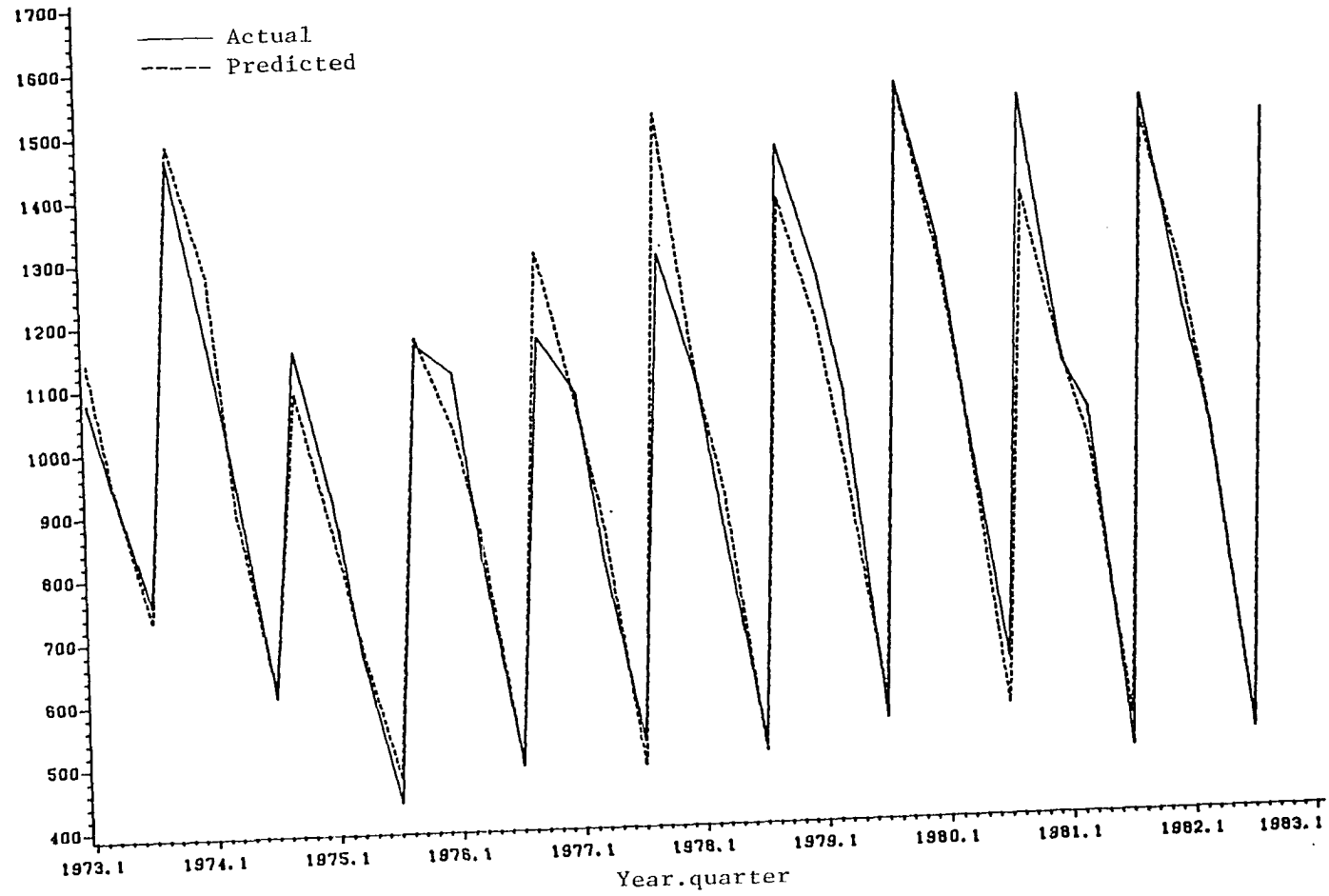
Mil. bu.

Figure 7.1. Predicted and actual corn feed use
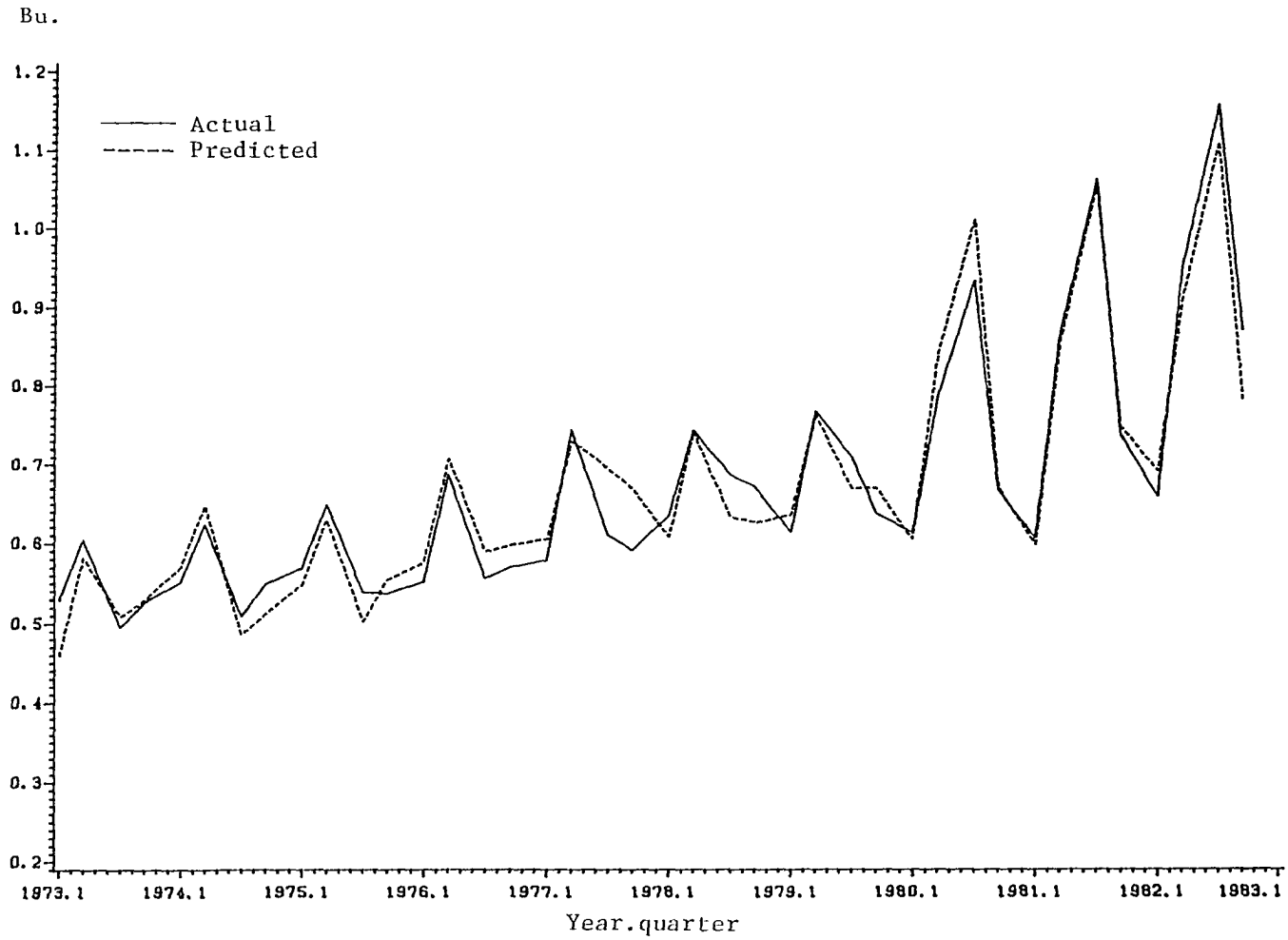
Figure 7.2. Predicted and actual per capita corn FSI use

Mil. bu.

Figure 7.3. Predicted and actual corn exports

Mil. bu.
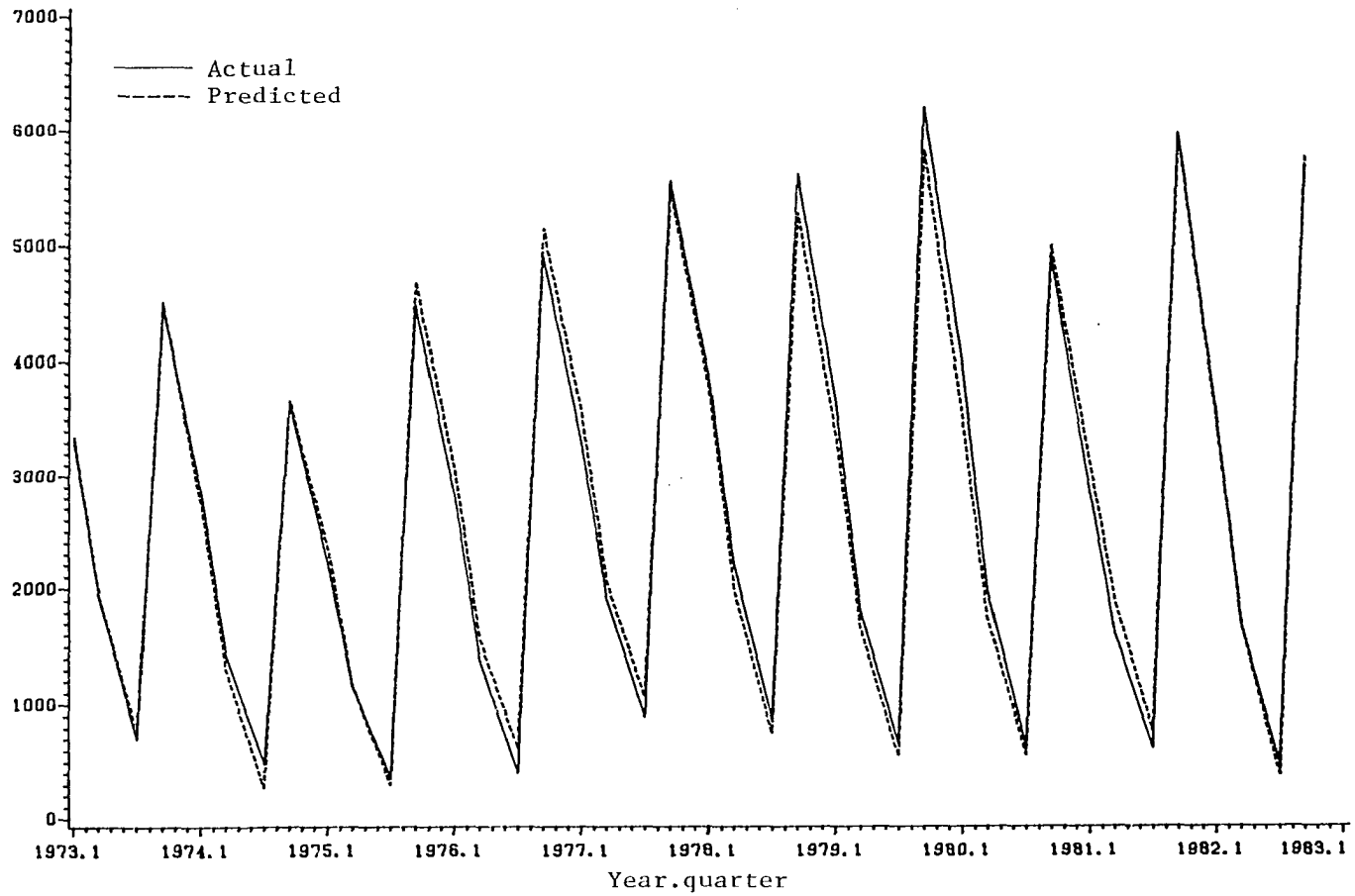
Figure 7.4.   Predicted and actual commercial stocks of corn
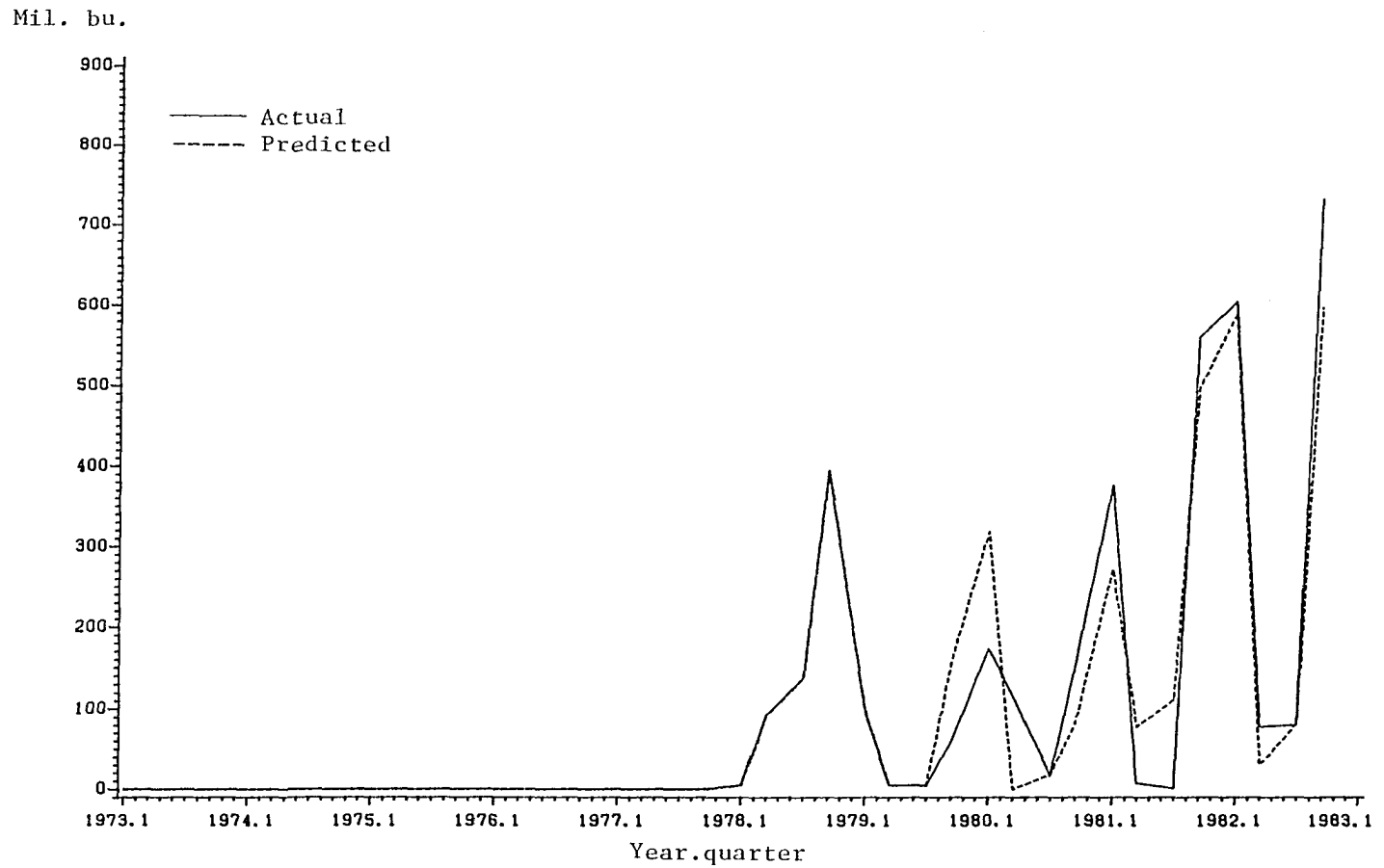
Mil. bu.

Figure 7.5.   Predicted and actual placements of corn into the Farmer-Owned Reserve

Mil. bu.
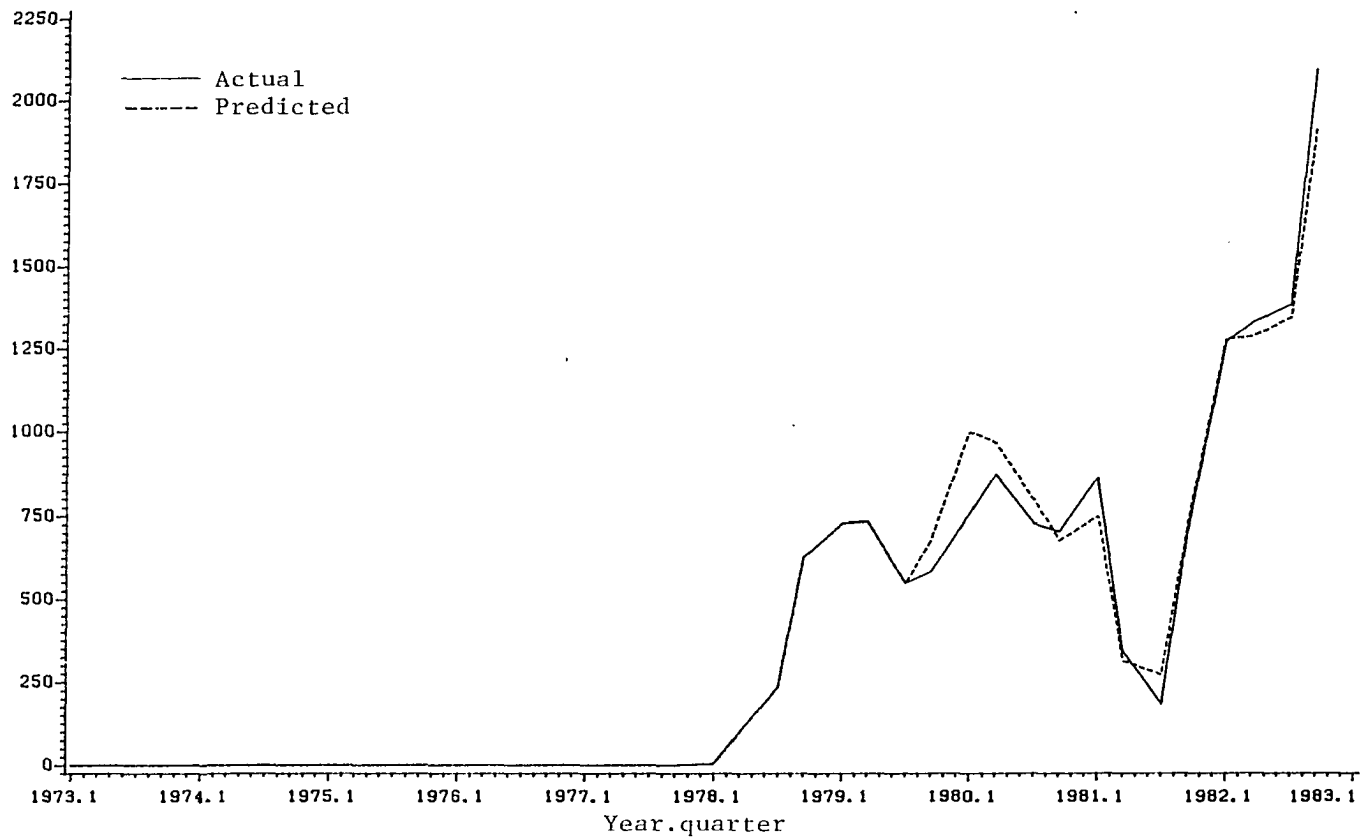
Figure 7.6.   Predicted and actual Farmer-Owned Reserve stocks of corn
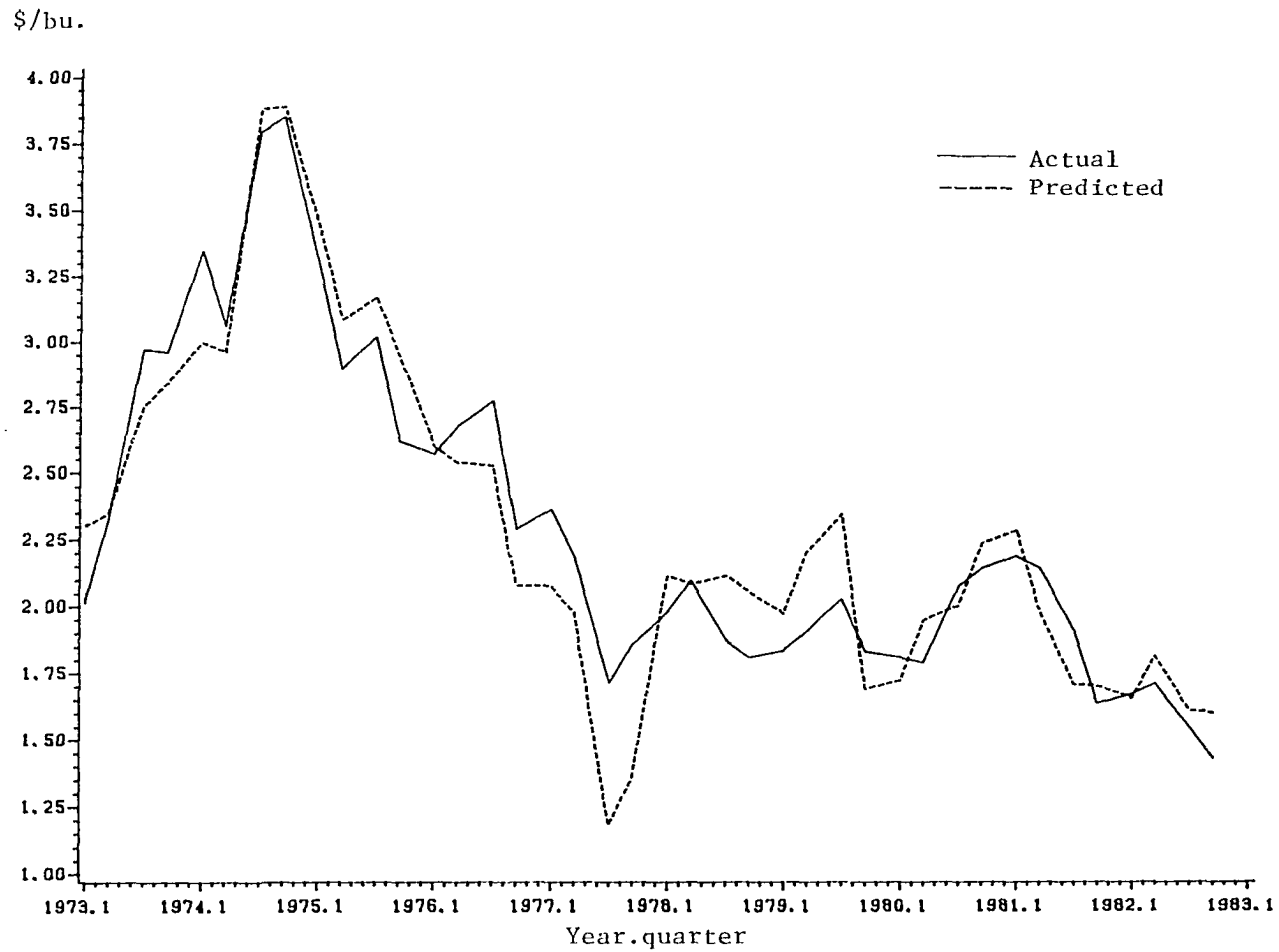
Figure 7.7.   Predicted and actual farm price of corn deflated by FPI

$/cwt.

Year.quarter

Figure 7.8. Predicted and actual feeder steer prices deflated by FPI

$/cwt.
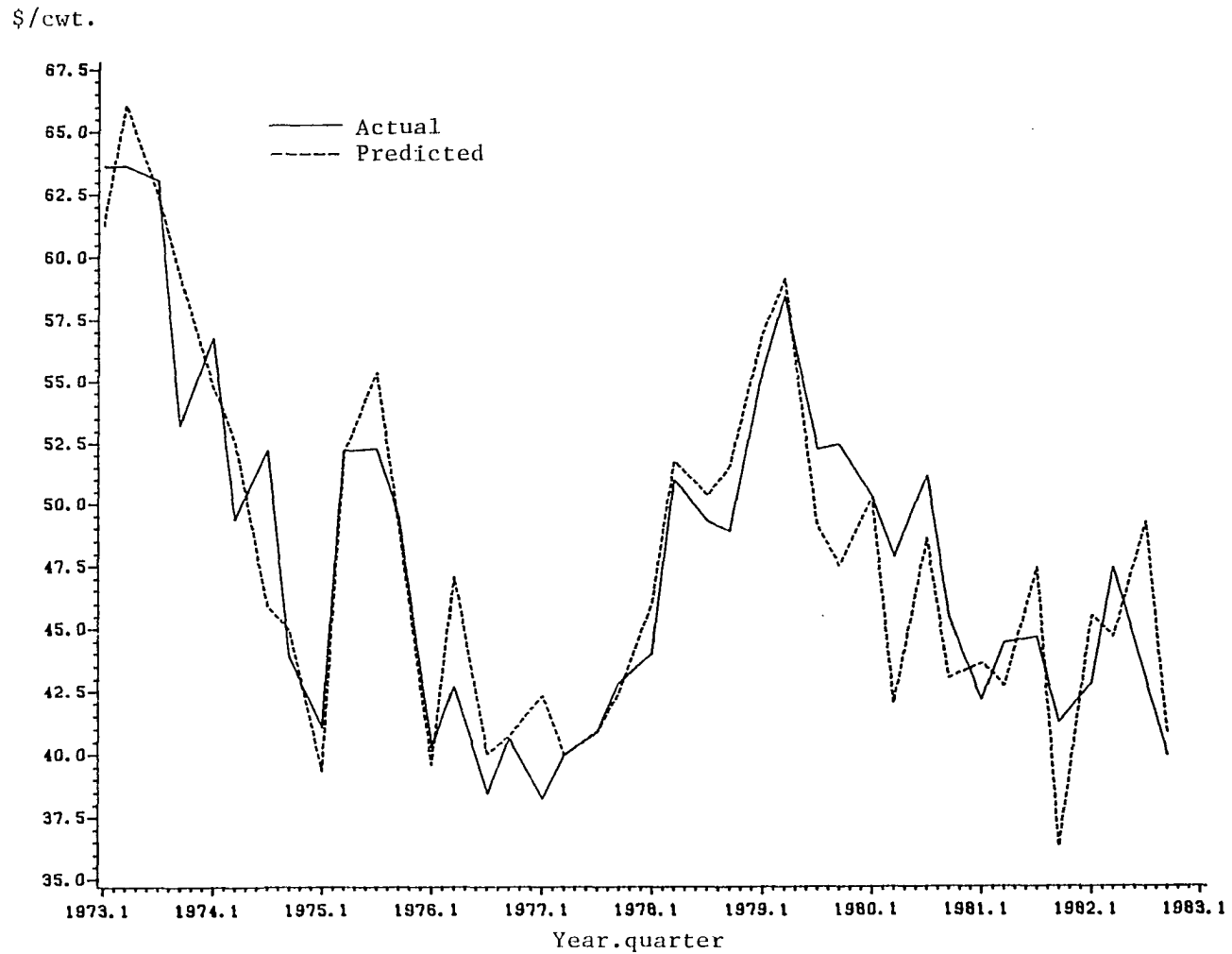
Figure 7.9.   Predicted and actual choice slaughter steer prices deflated by FPI

Thou. hd.

12000

11500 —— Actual
------ Predicted

11000

10500

10000

9500

9000

8500

8000

7500

7000

1973.1   1974.1   1975.1   1976.1   1977.1   1978.1   1979.1   1980.1   1981.1   1982.1   1983.1

Year.quarter
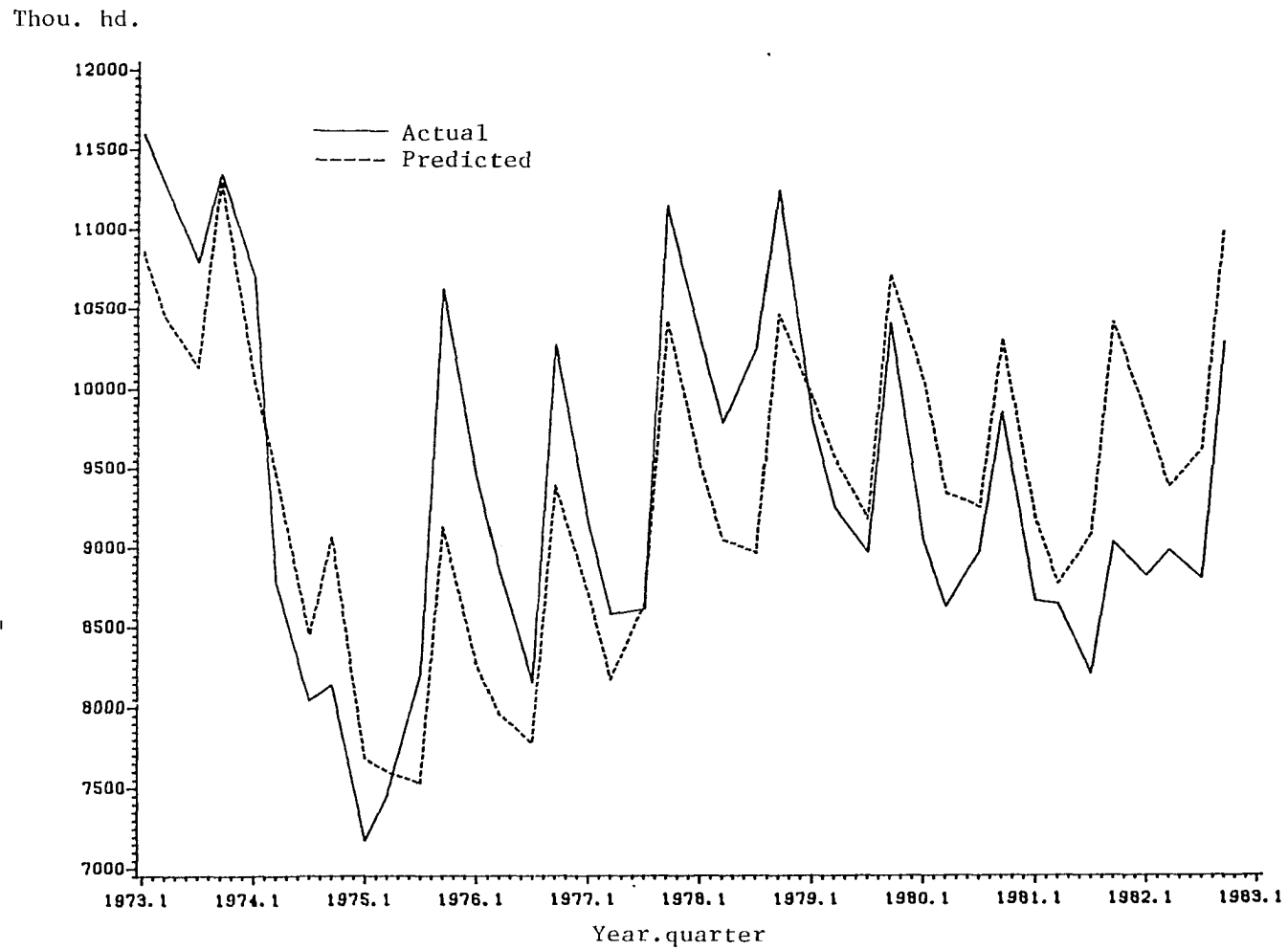
Figure 7.10.   Predicted and actual cattle on feed, 13 states

163
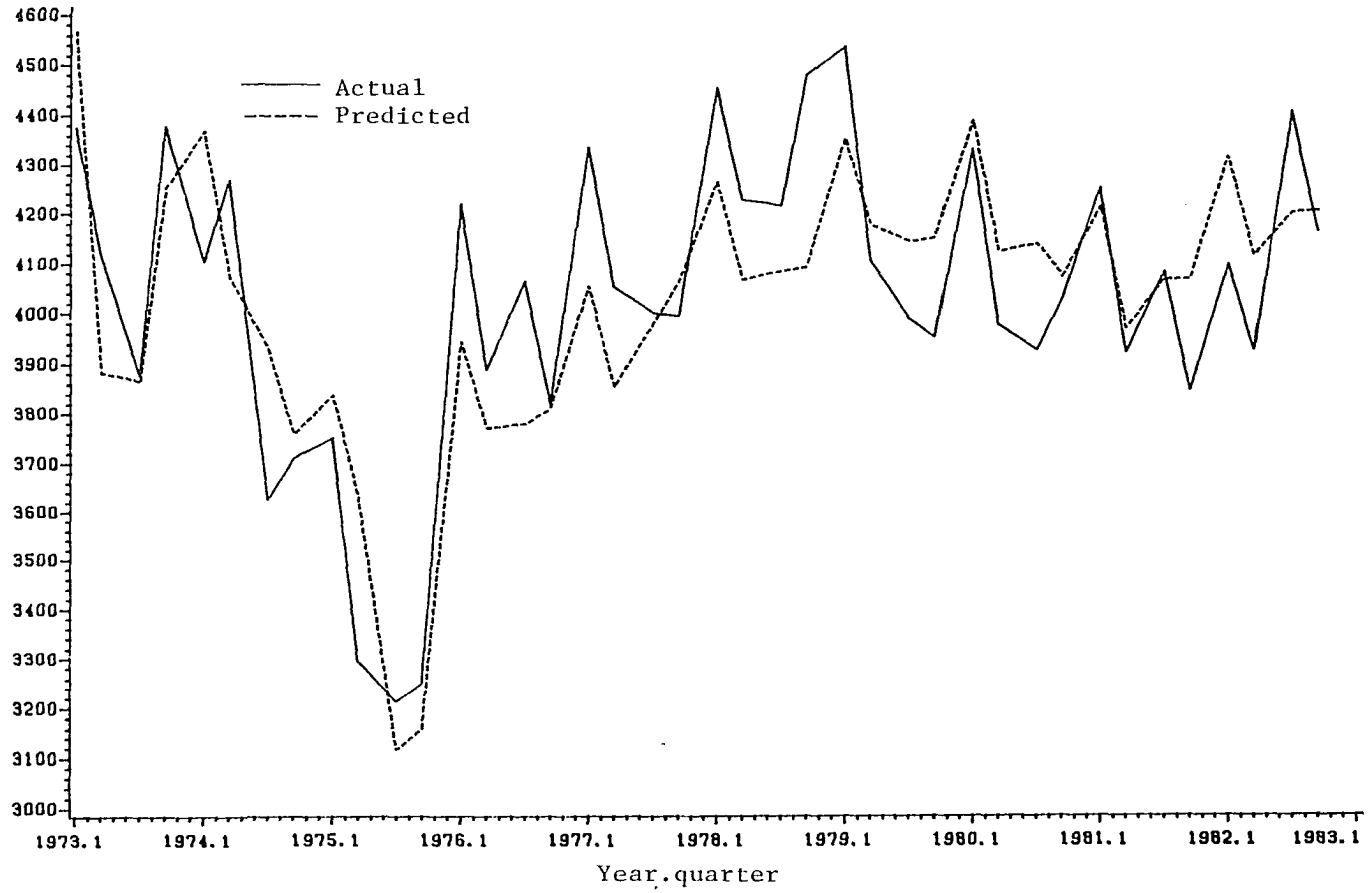
Mil. lbs.

Figure 7.11. Predicted and actual production of fed beef

$/cwt.

Figure 7.12.   Predicted and actual barrow and gilt prices deflated by FPI

Mil. lbs.

Figure 7.13. Predicted and actual production of pork

¢/lb.

Figure 7.14.   Predicted and actual farm price of broilers deflated by FPI

¢/lb.

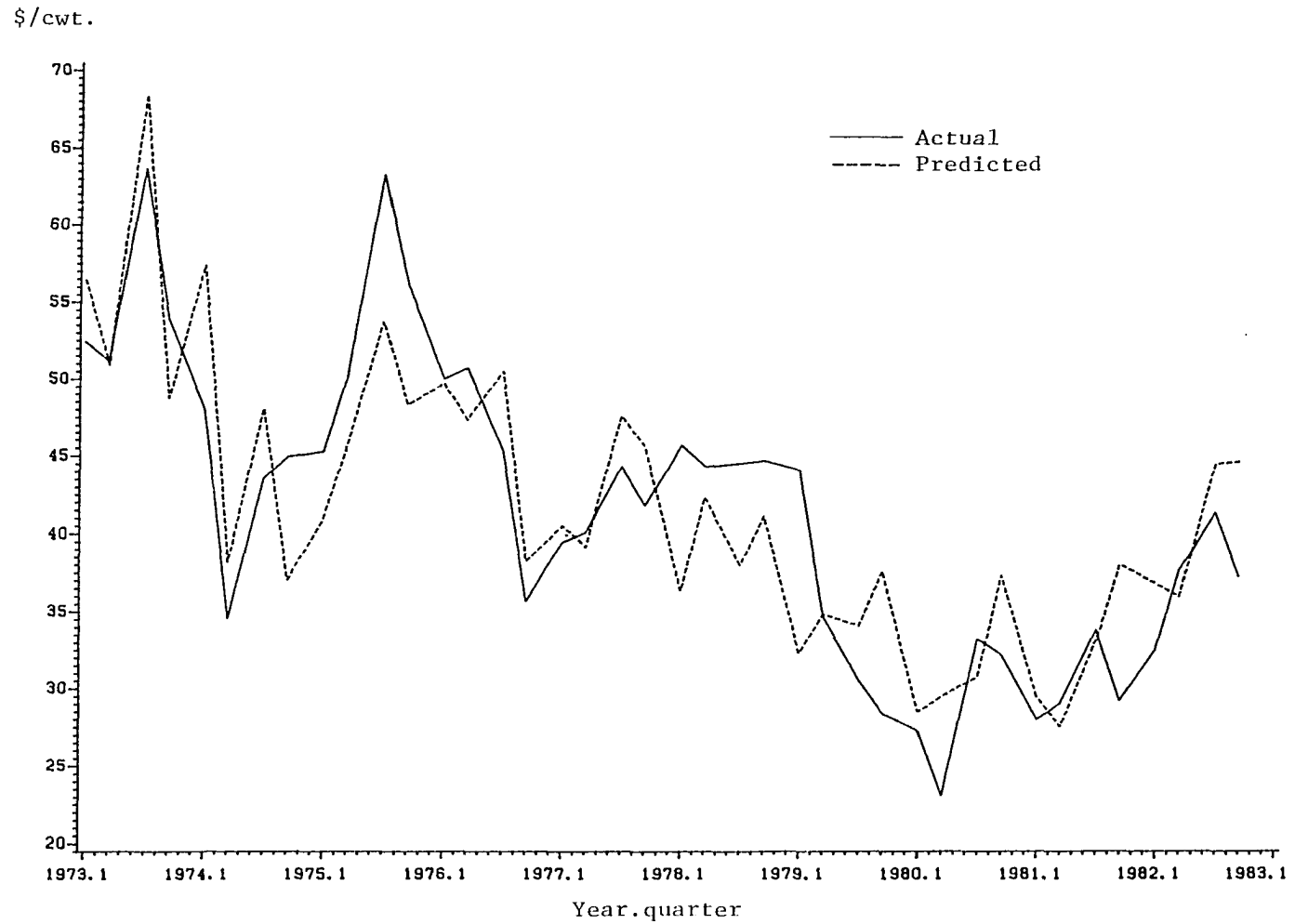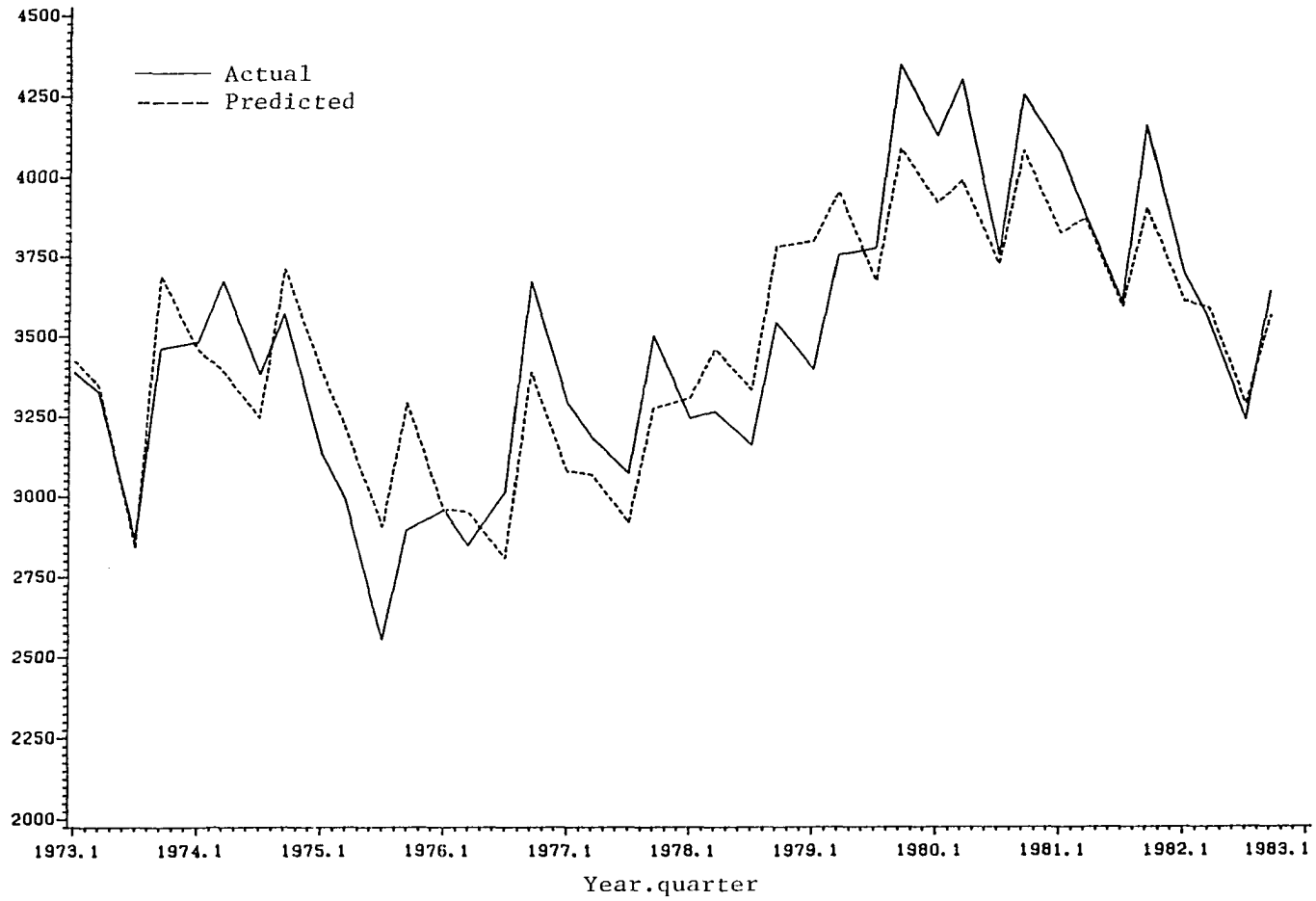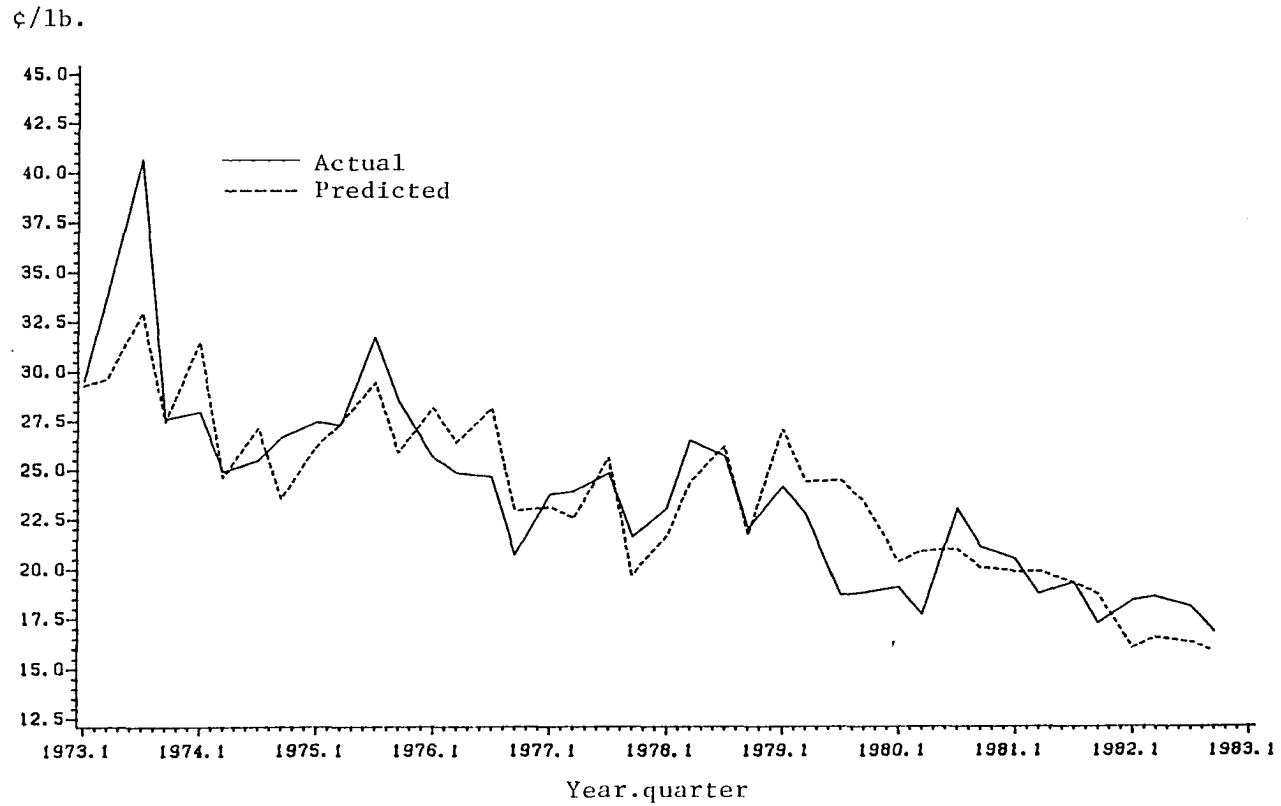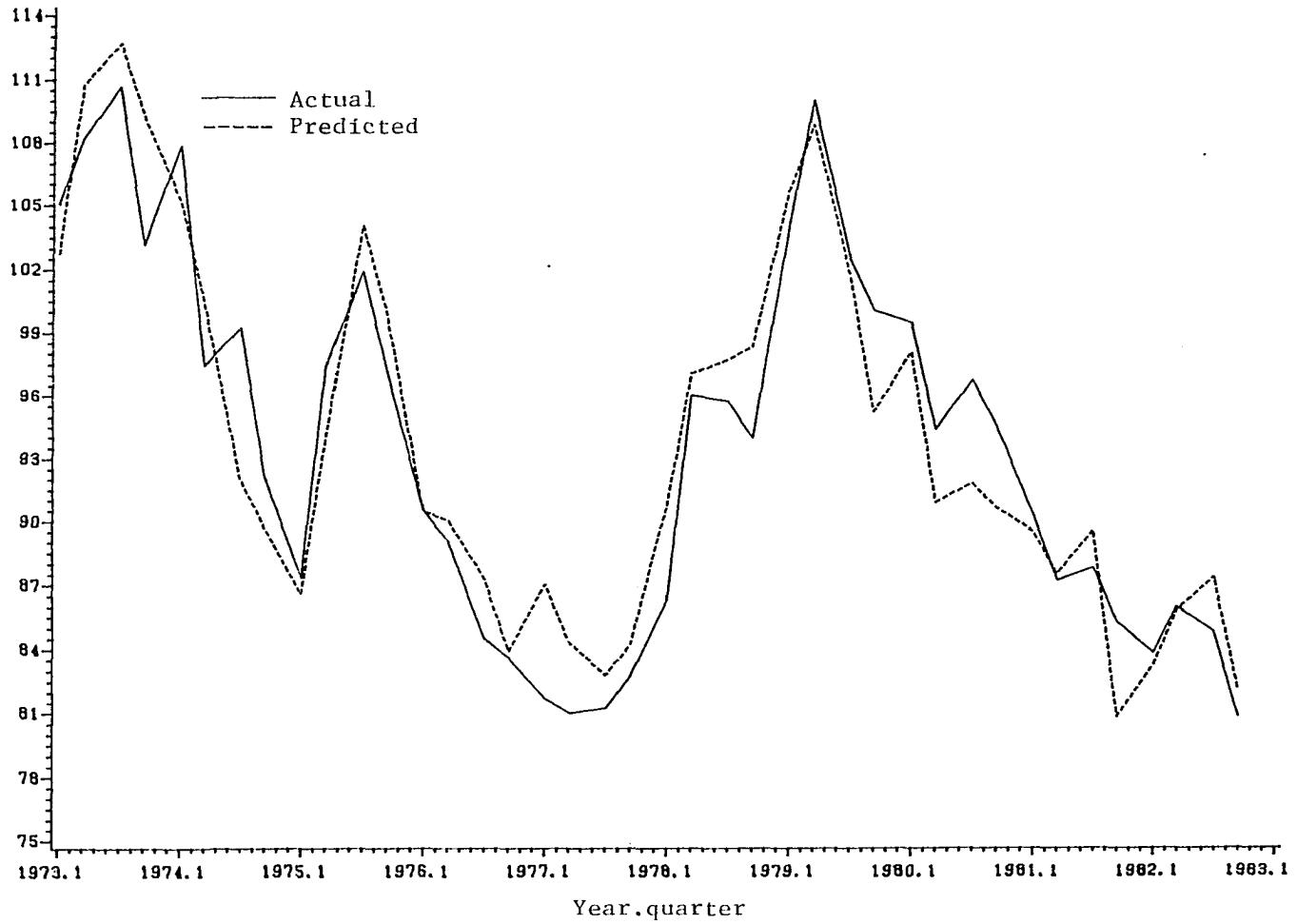Figure 7.15.   Predicted and actual choice retail beef prices deflated by CPI

168

¢/lb.

Figure 7.16. Predicted and actual choice beef farm-retail price margins

Table 7.1 Historical simulation accuracy of the model, 1971IV – 1982IV

	Variable	RMSPE	U_B	U_R	U_D	U
Corn	QCRNFEED	6.37	0.00	0.01	0.99	*
Market	QCRNFSIC	6.33	0.00	0.08	0.92	0.09
Block	QCRNEX	14.87	0.01	0.07	0.92	*
	ICRN	16.27	0.00	0.11	0.88	*
	PLACE	40.92	0.03	0.94	0.03	0.12
	REDEMP	2.88	0.09	0.38	0.52	0.04
	FORSTK	9.18	0.08	0.00	0.92	*
	APCRN[a]	1.06	–	–	–	–
	XCRN[a]	1.47	–	–	–	–
	RPCRN	12.35	0.00	0.57	0.43	0.05
	GCAU	2.89	0.01	0.16	0.83	*
Beef	BFCWS[a]	0.86	–	–	–	
Production	RPFDRS	7.50	0.02	0.38	0.60	*
Block	COF	7.62	0.00	0.17	0.83	*
	XFBF	4.48	0.01	0.00	0.99	*
	RPFBF	6.03	0.00	0.17	0.83	*
	RCFPI	164.87	0.02	0.08	0.90	0.25
Pork	SOWF	5.59	0.00	0.10	0.90	*
Production	PIGCRP	5.59	0.00	0.08	0.92	*
Block	SOWSLT	14.37	0.00	0.23	0.77	*
	BGSLT	5.61	0.00	0.21	0.79	*
	XPK	5.89	0.00	0.19	0.81	*
	RPPK	14.93	0.01	0.39	0.60	*
Broiler	XBRL	2.86	0.01	0.09	0.90	*
Production	RPBRL	10.55	0.00	0.20	0.80	*
Block						
Retail	QTBFC	3.94	0.00	0.09	0.91	*
Demand and	QPKC	5.86	0.00	0.28	0.72	*
Margin	QBRLC	2.98	0.01	0.11	0.88	*
Block	MFBF	2.95	0.01	0.21	0.78	*
	MPK	6.39	0.01	0.38	0.61	*
	MBRL	5.06	0.00	0.03	0.97	*
	RPRCBF	3.08	0.01	0.13	0.86	*
	RPRPK	6.76	0.01	0.30	0.69	*
	RPRBRL	6.74	0.00	0.09	0.91	*

[a]No Theil statistics were computed for annual variables.
* U < 0.009.

regression proportion reflects that portion of the simulation error attributable to the regression coefficient of actual values on predicted values being different from one. The disturbance proportion measures the percentage of the error attributable simply to residual variation. The ideal distribution of these coefficients is $U_B = U_R = 0$, and $U_D = 1$.

Error statistics for only the real price variables have been reported in Table 7.1, since deflation by an exogenous variable has no effect on the root mean squared percent error formula. For the same reason, the meat consumption variables are reported in per capita terms, as they were estimated.

Several general observations stand out in the graphs and computed statistics in the table and figures. For instance, the errors are noticeably larger in the price variables than in the inventory and demand components of the model. Moreover, the model's predictions of farm level variables tend to be less accurate than those at the retail level.

Reasons for the inferior performance of the price variables of the model relative to others rest largely with the fact that none of the behavioral functions (with the exception of the price of feeder cattle relation) were normalized on price. Heien, Matthews, and Womack (1973) for example, have emphasized that prices are typically forecasted with less certainty when the forecasting model contains no price dependent estimated relations. Here, as in most applications, prices were determined within the model by the intersection of demand and supply. Thus, variations in the forecasted prices of the system embody errors originating from both the supply and demand specifications of the model.

The greater predictive power of the retail demand, margin, and price relationships is largely the result of the structural specification of these equations relative to that employed in the farm production relations. Obviously the dynamics involved in determining levels of livestock inventories and production are much greater than those involved in the determination of the retail components of the model. Furthermore, a large number of the causal variables in the farm production equations are endogenously determined. Hence, there are fewer predetermined variables in the equations to reset each period's solution in the simulation exercise.

As illustrated by the simulation statistics, the feed and FSI demand equations perform quite well in replicating the past. The export demand and commercial stock equations perform suitably, but not quite as well. This characteristic is typical of most modeling efforts as structural knowledge is strongest with respect to domestic demand relations for agricultural products. Generally, empirical knowledge tends to be weaker regarding stock demands and foreign demands, primarily because of the unobservable expectations influencing the demand for stocks, and the extreme random component present in export demand relations.

One potentially troubling statistic in the corn market block relates to reserve placement behavior. The high root mean squared percent error of this variable, however, must be viewed in consideration of the fact that placements are quite variable on a quarter to quarter basis, and at times approach zero. Under such circumstances, a small error in prediction translates into a very large percentage error, in spite of the fact that the equation performs reasonably well. The extreme price sensitivity of this

variable is the cause of most of the error in the equation, and tends to induce an overprediction of placements when placements are low. FOR stocks are predicted well, although the statistics point out some bias -- most of which is traceable to the placements equation.

Choice steer prices and feeder cattle prices are tracked extremely well in the system. As evidenced by the plot of cattle on feed, this variable exhibits some upward bias in the latter periods, not captured in the error statistics. However, given the dynamic structure of the equation, and the accuracy of the beef model in predicting prices, the result is not considered troublesome. Similar to the FOR placement variable, caution should be exercised in the interpretation of the simulation statistics for the cattle feeding profitability index (RCFPI). Because the variable always assumes values close to zero, the poor statistics generated by the historical simulation are not necessarily evidence of a poor statistical relationship.

The pork equations and price perform the weakest of the three livestock markets. A large amount of the variation in the farm price of pork compared to that for the price of beef is traceable to the specifications of the respective production equations. The production of pork in the specification is perfectly inelastic, whereas, beef production does exhibit some current period price response, thus tending to decrease instability in the generated beef prices of the model.

For comparative purposes, the simulation results for major variables in the model are presented in Table 7.2 with those reported for the same forecasted variables in two prior studies. The Martin (1983), and Arzac and

Table 7.2 Comparison of the forecasting accuracy of the model in this study with previous studies

Variable name in this study	RMSPM	Martin[a] variable	RMSPM	Arzac and Wilkinson[b] variable	RMSPM
Corn	QCRNFEED	6.9	XDC[c]	7.5	XDC[c]	9.3
Market	QCRNFSIC	6.3	-	-	-	-
Block	ICRN	7.1	ICT	10.3	ICC	14.6
	APCRN	1.1	ACP	2.0	AP1	2.9
	XCRN	1.5	COSPRUS	3.2	XSC	3.3
	PCRN	10.1	PCORN	18.0	PG1	13.8
Beef	COF	7.5	PF[d]	10.9	IP	7.1
Production	BFCWS	0.9	BCOWS	2.4	KB	4.1
Block	PFDRS	7.9	RBSP	11.8	PF5	20.5
	XFBF	4.4	FSHBS	8.7	XS1	5.6
	PFBF	6.6	STP	11.9	PF1	13.3
Pork	XPK	5.7	PKS	8.3	XS3	7.8
Production	PPK	15.1	HOP	24.1	PF3	15.2
Block						
Broiler	XBRL	2.7	CHPDN	3.9	XS4	3.2
Production	PBRL	11.1	CHFP	15.8	PF4	18.1
Block						
Retail	QTBFC	4.0	XTB	6.7	XD1	5.4
Demand and	QPKC	5.6	XPK	8.0	XD3	8.0
Margin	QBRLC	2.9	XCN	4.0	XD4	4.5
Block	PRCBF	3.1	PCB	7.9	PR1	10.4
	PRPK	7.2	PPK	12.9	PR3	10.9
	PRBRL	7.2	PCN	10.6	PR4	12.8

[a]See Martin (1983, p. 212-213).
[b]See Arzac and Wilkinson (1979, p. 303).
[c]Total domestic corn disappearance.
[d]PF denotes quarterly cattle placements not cattle on feed.

Wilkinson (1979) studies were chosen for comparison, because both entail

quarterly models of the corn/beef/pork/broiler markets similar in structure

to the one developed here. Because root mean squared error as a percent of

the mean (RMSPM) was the only reported statistic in the Arzac and Wilkinson

paper, the forecasting accuracies in the table are presented in terms of this statistic rather than RMSPE.

Strictly on the basis of the reported statistics, the model developed in this study generated better forecasts over the historical sample period than either of the other two models, for every variable except cattle on feed. For many market variables, the model substantially outperforms the other two. This occurs with respect to the majority of variables in the corn market, the farm prices of fed beef and feeder cattle, and the variables in the retail demand block.

There are some general qualifications to this result. For example, the historical periods used in the Martin, and the Arzac and Wilkinson simulations were both 1965I - 1975IV. Although most of this period entailed relatively stable and flat prices, the mean values for many variables in the studies were lower than the means for the same variables in the 1971 - 1982 simulation period in this study. Thus, for the same degree of predictive accuracy, the RMSPM statistic computed in the other two studies would possess some upward bias relative to that computed for this model. Additionally, these two studies included the nonfed beef market in the model's specification. Because nonfed beef slaughter is largely a residual component of the total beef slaughter, both models encountered difficulty in accurately representing the production of this classification of beef. Although not likely to be large, errors in tracking nonfed beef slaughter in the two models, may be introducing unnecessary error in the other components of the beef market, and hence, the entire models.

Nevertheless, the corn-livestock model developed for this analysis does
perform appreciably better for the majority of variables than either of the
other two models used in the comparison. This result is quite encouraging,
and lends a great deal of confidence to the estimated results.

Ex Post Forecasts of the Model

The most stringest examination of a model involves testing its ability
to forecast outside the period of estimation. To investigate the ex post
forecasting properties of the model, forecasts were generated for the
1982/83 crop year. Root mean squared percent error statistics corresponding
to the four quarterly forecasts, and percent errors in each quarter are
presented in Table 7.3 for the same variables that appeared in Table 7.1

Because the 1982/83 crop year embodied the payment-in-kind (PIK)
program for corn producers, some initial forecasting problems occurred.
Drought-induced high prices, and pledges for PIK payments resulted in
substantial redemptions of corn from the FOR program in the last quarter of
the 1982/83 crop year. Of the 2.6 billion bushels of corn in the reserve
program in July, 1.6 billion bushels was committed as either pledges for PIK
payments or for delivery to the CCC under the "PIK-for PIK" procurement
program. Because the redemption equation was not equipped to quantify
redemptions from the program for these purposes, the equation was "turned
off" in this period, and redemptions exogenized. The results in the table
thus represent the model's forecasts for the four quarters, with redemptions
taken as given in the last quarter of the crop year.

As a whole, the model performs quite well in forecasting four quarters
ahead. For most of the variables, the error statistics are somewhat higher

Table 7.3 Ex post forecasting accuracy of the model, 1982IV - 1983III

	Variable	RMSPE	Percent error by quarter			
			IV	I	II	III
Corn	QCRNFEED	12.8	-2.4	-5.8	-24.3	5.1
Market	QCRNFSIC	11.9	-10.8	-0.4	-10.4	-18.5
Block	QCRNEX	12.5	2.7	-7.5	7.7	-22.4
	ICRN	188.1	-1.0	2.1	26.1	375.4
	PLACE	91.5	-15.6	-0.3	153.0	-99.4
	FORSTK	4.2	-5.4	-4.2	-2.5	-4.1
	APCRN[a]	2.1	--	--	-4.1	--
	XCRN[a]	1.3	-2.6	--	--	--
	RPCRN	12.6	14.6	-4.2	13.6	15.0
	GCAU	2.3	1.2	2.6	1.1	3.4
Beef	BFCWS[a]	0.1	0.1	--	--	--
Production	RPFDRS	21.2	16.6	15.4	17.4	31.5
Block	COF	5.2	2.9	7.9	2.4	5.7
	XFBF	5.2	-1.6	-0.6	-2.4	-10.1
	RPFBF	16.6	18.3	6.2	13.5	23.3
	RCFPI	82.6	31.7	51.4	20.5	-152.3
Pork	SOWF	3.8	-1.9	0.5	0.7	7.2
Production	PIGCRP	3.7	-1.9	0.5	0.7	7.2
Block	SOWSLT	10.0	-2.0	-7.2	-11.4	-14.7
	BGSLT	1.9	-1.5	-0.03	-3.1	-1.7
	XPK	3.1	-3.1	-1.7	-4.4	-2.9
	RPPK	19.6	30.7	-1.9	24.2	2.8
Broiler	XBRL	2.4	2.7	0.6	0.8	3.8
Production	RPBRL	19.1	-10.1	-11.8	-20.1	-28.5
Block						
Retail	QTBFC	5.0	-1.5	0.6	-2.3	-9.6
Demand and	QPKC	3.1	-3.0	-1.6	-4.3	-2.8
Margin	QBRLC	2.5	2.9	0.7	0.8	4.0
Block	MFBF	3.8	-0.0	4.4	2.1	5.9
	MPK	4.4	-2.5	5.4	-6.5	0.1
	MBRL	3.1	-2.5	-3.7	-4.4	-0.7
	RPRCBF	6.7	4.6	4.9	5.2	10.4
	RPRPK	4.1	7.2	3.2	1.9	0.9
	RPRBRL	9.2	-5.2	-6.7	-10.4	-12.6

[a]Annual equations.

than those reported in Table 7.1. This is to be expected since information

contained in the data for 1982/83 was not incorporated into the estimation

of the model's parameter sets. For several variables, however, the RMSPE

statistics were lower in the ex post forecast period than in the historical

period. These variables include total exports of corn, farmer-owned

reserves, corn production, inventories of beef cows, cattle on feed and

grain consuming animal units, and all the variables of pork production

block.

The forecast results for commercial stocks of corn, and placements into

the FOR require a close examination. Specifically, the percent error in

commercial stocks for the last quarter of the crop year was extremely high.

An examination of this result indicated that the model did capture the

turning point in stocks in this period, but failed to predict the magnitude

of the change in ending stocks from the previous quarter. Ending commercial

stocks in the 1982 crop year were greatly influenced by the high summer

prices and PIK entitlements, and were over two and one-half standard

deviations below average ending stocks for that quarter over the sample

period. With this in mind, and considering that the model was predicting

carryover stock levels well below the average, the result was not considered

troublesome. Based on the percent errors, corn placements in the third and

fourth quarters of the crop year were also predicted quite poorly. However,

the percent errors are extremely misleading in this context, because

placements were very close to zero in the two quarters. Total placements in

the two quarters were only 41 million bushels compared with 1392 million

bushels in the first two quarters of the crop year. In actuality, the

equation predicted placements quite well as evidenced by the error

statistics in the first two quarters, and the statistics for total FOR

stocks through the year. The RMSPE statistic for the cattle feeding

profitability index was similarly distorted, as it was in Table 7.1, by

small values of the variable.

Although some variables do exhibit a certain degree of bias in the

forecasts, the results in this section indicate that the model performs

appreciably well in the beyond-sample forecasts. The use of a particular

year in the ex post forecast, is of course arbitrary and may well have

resulted in misleading error statistics for some variables, either up or

down. This problem is, however, inevitable in any use of simulation

techniques for model validation.

Multiplier Analysis

A dynamic simulation was performed in the first section of the chapter

to test the goodness of fit of the model, and its stability over the

historical period when conditioned on the actual values of the exogenous

variables. In this section, the values for selected exogenous variables are

altered in some fashion from their historical paths. Under these imposed

conditions, simulation passes are conducted for the purpose of examining

whether the structure of the model tends to dampen or amplify shocks to the

system. Specifically, attention is focused on the patterns of adjustment

the endogenous variables follow in reconverging to a new equilibrium, and

whether the adjustment responses are theoretically consistent.

Dynamic multipliers for the exogenous shocks cannot be explicitly

computed from the reduced form, because the model contains nonlinear

relationships. The nonlinear features of the model furthermore guarantee that the impacts of external shocks to the system will vary depending on the conditions at the time the shock is encountered. Consequently, implicit multipliers calculated from the simulation exercises are presented for systematic demand and supply side shocks imposed on the model at two separate points in time. These multipliers measure the effect of the exogenous shocks on the values of the endogenous variables through time, and are computed as deviations of the paths taken by the endogenous variables from the time paths generated for those variables in the "base" simulation. The base simulation, or baseline corresponds to the dynamic solution of the model presented in the first section of the chapter in which the historical values of the exogenous variables conditioned the model.

Impact, interim, and long term multipliers for key variables of the corn-livestock sector are presented in Table 7.4 for a permanent 100 million bushel per quarter increase in corn exports to the USSR. The computed impact multipliers indicate the first quarter impact, whereas interim multipliers reflect the intermediate run effects of the export shocks on the endogenous variables. Because total or equilibrium multipliers cannot be calculated from the model, a long term multiplier is presented indicating the impact of the sustained shock in the last year of the sample period. In the true long run, the market price would adjust sufficiently so that any change in the quantity demanded for utilization would be met by an equal change in the quantity produced, with no long term building or drawing down of total stocks.

Table 7.4. Multipliers for a permanent 100 million bushel increase in corn exports to USSR

Endogenous variable	Units	Initiated in 1975IV				Initiated in 1979IV			
		Impact	Year[a]		Long term[b]	Impact	Year		Long term
			1	2			1	2	
Corn									
Domestic									
Feed	mil. bu.	−41	−161	−246	−76	−25	−91	−103	−95
FSI	mil. bu.	−3	−20	−24	−8	−2	−12	−8	−8
Stocks									
Commercial	mil. bu.	−51	−167	−143	208	−9	49	171	269
FOR	mil. bu.	---	---	---	−742	−60	−314	−633	−901
Exports	mil. bu.	95	348	264	272	96	368	320	300
Production	mil. bu.	0	0	18	26	0	0	12	27
Price	$/bu.	0.15	0.23	0.26	0.12	0.12	0.16	0.16	0.14
Livestock and Meat									
Inventory									
Beef cows	thou. hd.	0	0	−26	267	0	0	−16	−42
Cattle on feed	thou. hd.	−88	−414	−506	−112	−52	−185	−208	−195
Sows farrowing	thou. hd.	0	−20	−170	−83	0	−12	−78	−98
Production									
Fed beef	mil. lb.	−16	−163	−394	−108	−10	−88	−167	−162
Pork	mil. lb.	0	1	−66	−95	0	1	−36	−93
Broilers	mil. lb.	0	−22	−80	−18	0	−13	−35	−28
Prices									
Farm									
Choice steers	$/cwt.	0.28	0.57	1.21	0.54	0.22	0.40	0.74	0.79
Feeder cattle	$/cwt.	−0.59	−0.62	0.29	−0.10	−0.49	−0.37	0.21	0.44
Hogs	$/cwt.	0.03	0.03	0.61	0.88	0.02	0.02	0.45	0.93
Broilers	¢/lb.	−0.04	0.11	0.58	0.29	−0.03	0.10	0.37	0.37
Retail									
Choice beef	¢/lb.	0.49	1.25	3.21	1.50	0.38	0.92	1.96	2.15
Pork	¢/lb.	0.04	0.05	1.00	1.85	0.03	0.03	0.77	1.86
Broilers	¢/lb.	−0.05	0.18	1.10	0.51	−0.04	0.17	0.64	0.66

[a] Multipliers in first and second crop years following export shock.
[b] Multiplier in last crop year of historical period.

Most of the corn market adjustments to the export shock take place in the first two years, with the maximum one-quarter responses occurring four to six quarters following initiation of the shock. After two years, the market adjustments taper off, suggesting that the model dampens the shock over time as the true market would. The sharpest price effects are noticed in the fourth quarter of each crop year, when available supplies are the tightest. The inventory responses are somewhat longer in the livestock sector because of technical constraints. Adjustments in the livestock sector begin to exert a noticeable effect on the demand for corn in the second year after the export increase.

When subject to the autonomous increase in exports, the model indicates that the price of corn in the first quarter would rise about $0.15/bushel. Total exports do not rise by the full 100 million bushels, because the price increase chokes off a small amount sold commercially elsewhere. The shock when initiated in 1975, induces a 44 million bushel decrease in domestic utilization, and a 51 million bushel draw down in commercial stocks in the first quarter. Interestingly, the same shock imposed in 1979, exerts a much smaller impact on domestic utilization and stocks, with the heaviest burden falling on reserve placements which are reduced by 60 million bushels. In the livestock markets, the first quarter responses are relatively minor. Higher current corn prices reduce the expected profitability of livestock feeding and cause the number of cattle on feed in the first quarter to drop by 88 thousand head, or roughly one percent. The livestock industry effects of the permanently higher corn prices primarily unfold in the first and second years. All livestock inventories are reduced as the retention of

animals for breeding purposes is cut back while culling rates become moderately heavier. The number of sows farrowing in the second year is reduced by 170 thousand head, while the number of cattle on feed drops by 506 thousand head. This translates into reductions of 5.6 percent and 6.3 percent, respectively. Although the production of pork exhibits a transitory increase, as more sows are marketed for slaughter, the production of all meat classes decreases after the first year.

By the end of the historical period, the impacts of the export shock have tempered, and are distributed in a somewhat different manner than in the initial periods. Based on an average of the long term multipliers for the two time periods, the annual 400 million bushel increase in exports to the USSR actually increases total exports by only 286 million bushels. The effects on domestic utilization are smaller in the last year with feed demand falling off by 86 million bushels, and FSI demand by 8 million bushels. Interestingly enough, the rate of accumulation of commercial stocks is more rapid in spite of higher prices. The slowing down of reserve stock accumulation has sufficiently stimulated the demand for speculative stockholdings that it overpowers the price effects, and causes commercial stocks to build. Nevertheless, total stock accumulation is smaller, moderating the upward price pressure brought about by the demand shock.

In general, the price effects in the last year are also smaller than the adjustments in earlier periods. The long run price of corn rises about $0.12/bushel, while the price of choice slaughter steers increases $0.66/cwt. The price of feeder cattle falls slightly in certain periods reflecting the declining demand for cattle and calf placements on feed. At

the retail level, the long run changes in meat prices are minimal, with choice beef prices adjusting upward by $0.02/lb.

To provide further information on the market impacts of external shocks, multipliers for a supply side shock to the model are presented in Table 7.5. Illustrated in this table are the calculated multipliers for a permanent corn yield increase initiated in the same two periods as before.

The results indicate that the distributional impacts of the yield shock on the model are largely the same as for the export shock, but opposite in direction. The absolute price responses are larger because the yield increase adds from 50 - 75 percent more grain to the system than the export shock removed. The sharpest market adjustments again occur in the first two years, and taper off with the passage of time. Reduced corn prices encourage not only heavier feeding rates per animal, but with a lag increase the number of livestock on feed. By the end of the second year, increases in livestock numbers have induced a 9.6 percent increase in the demand for feed. In the second year following the shock in 1975IV, the demand for feed absorbs about two-thirds of the increase in production. In the long term, however, adjustments in domestic utilization are substantially smaller than in the initial years, with most of the production increase channelled to the export market, and the Farmer-Owned Reserve. With active operation of the FOR, the price of corn at the end of the sample period has fallen by $0.24/bushel compared with $0.36/bushel in the first two years. The response of the livestock industry also tapers off contributing to a weaker long term multiplier for feed demand.

Table 7.5. Multipliers for a permanent 10 percent increase in corn yields

Endogenous variable	Units	Initiated in 1975IV				Initiated in 1979IV			
		Impact	Year[a] 1	Year[a] 2	Long term[b]	Impact	Year 1	Year 2	Long term
Corn									
Domestic									
Feed	mil. bu.	94	326	400	180	70	230	184	205
FSI	mil. bu.	8	32	32	15	6	21	16	16
Stocks									
Commercial	mil. bu.	501	155	111	−429	508	−162	−351	−534
FOR	mil. bu.	---	---	---	1268	174	596	1058	1571
Exports	mil. bu.	10	100	205	212	11	84	136	176
Production	mil. bu.	613	613	593	732	769	769	609	727
Price	$/bu.	−0.34	−0.36	−0.36	−0.23	−0.35	−0.30	−0.21	−0.24
Livestock and Meat									
Inventory									
Beef cows	thou. hd.	0	0	58	−394	0	0	44	53
Cattle on feed	thou. hd.	200	548	620	134	150	288	250	256
Sows farrowing	thou. hd.	0	56	268	132	0	44	152	158
Production									
Fed beef	mil. lb.	37	316	576	196	28	220	276	276
Pork	mil. lb.	0	−4	132	152	0	−4	92	160
Broilers	mil. lb.	0	52	116	32	0	40	55	41
Prices									
Farm									
Choice steers	$/cwt.	−0.65	−1.01	−1.76	−0.97	−0.64	−0.92	−1.21	−1.34
Feeder cattle	$/cwt.	1.33	0.71	−0.59	0.17	1.39	0.45	−0.61	−0.67
Hogs	$/cwt.	−0.07	−0.05	−1.08	−1.39	−0.07	−0.04	−1.02	−1.54
Broilers	₵/lb.	0.08	−0.31	−0.87	−0.49	0.08	−0.33	−0.63	−0.60
Retail									
Choice beef	₵/lb.	−1.11	−2.40	−4.74	−2.65	−1.10	−2.26	−3.29	−3.65
Pork	₵/lb.	−0.08	−0.08	−1.89	−2.94	−0.08	−0.07	−1.83	−3.17
Broilers	₵/lb.	0.13	−0.51	−1.52	−0.87	0.12	−0.57	−1.11	−1.07

[a] Annual multipliers in first and second crop years following yield shock.
[b] Multiplier in last crop year of historical period.

It is interesting to note that the quarterly corn price adjustments to the yield shock are the smallest in the fourth quarter of ᵗᵉch crop year, whereas for the export shock the price adjustments were the most pronounced in the fourth quarter. By the last quarter of the crop year, the increase in production has already been allocated to the consumption channels by price adjustments in earlier periods. Hence, the available supply in the fourth quarter is essentially unchanged from what it was in the baseline, with the price response being minimal.

Similar to the demand shock, the influence of the FOR program is evidenced by the impact multipliers for corn prices. The first quarter price effects are the same for the shocks in 1975IV and 1979IV, although due to both larger yields and plantings, the production increase in 1979 was over 25 percent larger than in 1975. The FOR in 1979 soaked up 174 million bushels of the production increase in the first quarter, lessening the equilibrium price response to the shock.

CHAPTER VIII. EMPIRICAL EVALUATION OF THE FARMER-OWNED RESERVE
PROGRAM FOR CORN

Policy models are mathematical representation of economic systems
formulated for the purpose of anticipating and evaluating outcomes of
decisions that influence the functionings of the system. The econometric
model developed in Chapter VI assumes the role of a policy model in this
chapter for the purpose of examining the economic ramifications of
alternative grain storage policies on the markets of the corn-livestock
sector. Specifically, the objectives of the chapter are to assess through
econometric simulation, the implications of the Farmer-Owned Reserve program
on carryover stocks, production and utilization of corn, and corn and
livestock price levels and variability through time.

Description of Policy Alternatives

In order to evaluate the FOR program an alternative intrayear supply
management policy is needed. The alternative (i.e., No-FOR) policy employs
rules governing the accumulation and release of Commodity Credit Corporation
(CCC) stocks, designed in the analysis to replicate stock management
strategies in place prior to the inception of the FOR in 1977. Rules
characterizing the operation of the FOR and the alternative policy, and
revisions in the model's structure necessary to accomodate the alternative
policy are presented in this section. Each option implies different supply
management responses, and hence, affects the structure and functionings of
the markets in different manners. The policy rules implemented in the

analysis reflect the alternative price corridor objectives assumed for each storage option.

FOR policy option

The Farmer-Owned Reserve program formed the basis of the post-1977 grains policy. Because the corn-livestock model was specified to explain market behavior over the historical period, the management and operations of the FOR program are already built into the model. At low prices, the FOR placement equation depicts the amount of corn entering the program. Participation in the program is voluntary and depends on current prices, the provisions of the program, and the amount of eligible corn. As prices rise, the inventives provided to participants for holding reserve grain are relaxed in the model at two specific levels. Prices immediately above the trigger or release level activate the redemption equation which quantifies the amount of grain voluntarily reentering market channels. If the market price of corn reaches the FOR call level, all corn remaining in the program is immediately placed on the market until the price falls, or FOR stocks are completely liquidated.

Under this policy, CCC-owned stocks serve as a backup buffer stock. The trigger level for disposing of CCC stocks is 105 percent of the reserve call level prior to 1981, and 110 percent of the reserve release level after that time. Determination of ending government-owned stock levels is, for the most part, exogenous in the FOR model.

No-FOR policy option

The alternative program designed invoked in the analysis assumes only

the existence of the regular CCC loan program. With no formalized farmer or

government-owned buffer stock, the No-FOR model assumes total reliance upon

adjustments in CCC-owned stocks to moderate extreme price movements. The

amount of corn under nine month loan is not specifically handled in the

No-FOR model since it is reflected in the commercial stocks equation.

However, in the simulation exercise in the next section, the quarterly

carryover level of CCC stocks of corn is partially endogenized through a

series of adjustment rules.[1] These rules for determination of ending

CCC-owned stocks are as follows:

(1) If the seasonally adjusted annual price of corn[2] without
    intervention lies between the regular CCC loan level, and 115
    percent of that level, then ending CCC stocks equal beginning
    CCC stocks.

(2) If the seasonally adjusted annual price of corn without
    intervention falls below the regular loan level, then stocks
    of corn in the CCC accumulate on an even quarterly basis until
    the seasonally adjusted price is raised to the loan level.

(3) If the market price of corn in any quarter exceeds 115 percent
    of the CCC loan level, then CCC stocks are released until
    either the price falls below that level, or CCC-owned stocks
    are completely exhausted.

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[1]The only exception to these rules for determining CCC carryovers
occurs in the model in 1981II. CCC-owned stocks were increased by 128
million bushels in this period, consistent with actual CCC purchases of
corn, instituted at the time to offset the expected price depressing effects
of the Soviet grain embargo.

[2]The seasonally adjusted annual price of corn is computed as a weighted
average of the quarterly corn prices with the weights corresponding to
quarterly utilizations.

These stock adjustment rules are consistent with actual CCC adjustments during the decades of the 1960s and 1970s. Prices below the loan precipitate the accumulation of CCC stocks of grain via the forfeiture of grain under loan, while prices above the CCC release level bring these quantities back on the market.

Unlike the FOR option, incorporating this policy design into the model required some structural revisions. Because the reserve program is not in operation, the reserve equations and variables of the model were removed from the specification. In addition, the commercial stocks relationship was respecified and estimated over the historical period. The motive for reestimating the stocks equation initially reflected the desire to allow the price responsiveness of private stockholding to vary if need be, before and after introduction of the FOR. Introduction of the program in 1977 undoubtedly affected the structure of related markets by adding another price-responsive demand component. However, it was conjectured that the program may also have influenced the markets by causing a parametric drift in the structure of certain relationships. Because of its close interaction with the demand for grain for public stockholding, the commercial stocks equation was considered the most likely of the relationships in the model to have experienced a behavioral shift in 1977. To avoid a potential bias in the price stabilizing characteristics of the pre-1977 corn market structure, the commercial stocks equation was fitted to the period, 1969I - 1977III, with FOR stocks in the equation replaced by CCC stocks. Contrary to expectations, the estimated results yielded a relationship noticeably more price inelastic than the stocks equation in the FOR model. Moreover, the

implied rate of substitution between CCC stocks and commercial stocks was implausible in magnitude. Because of the poor performance of the equation, and in view of the objectives of the study, this approach to determining the structure of the commercial stock demand relationship in the No-FOR model was abandoned. The final form of the stocks equation appearing in the model is only a minor modification of the stocks equation in the FOR model. The same price elasticities were imposed on the No-FOR equation, and the CCC stock variable in the equation replaced by the sum of the CCC and FOR stocks, which together constitute "government-controlled" stocks. The equation was estimated over the entire sample period and takes the form:

ICRN = 3932.46 - 588.20*RPCRN + 274.93*Q4*RPCRN - 285.76*Q1*RPCRN
       (4.99)   (6.87)   (1.69)   (2.05)
                 [0.49]   [0.13]   [0.61]

   - 266.07*Q2*RPCRN + 0.629*D4*XCRN - 0.246*[CCCSTK + FORSTK]
     (1.77)   (4.93)   (2.77)
     [1.10]   [0.81]   [0.09]

   - 20.54*D23*APCRN - 2146.47*Q4 + 1443.48*Q1 + 1515.63*Q2   (8.1)
     (1.23)   (1.75)   (1.63)   (1.67)
     [1.38]

   (S/M = 0.07, R-SQUARE = 0.98, quarterly-OLS, 1971I - 1982III)

where:

       ICRN = ending commercial stocks of corn, mil. bu.

      RPCRN = average corn price received by farmers, deflated
              by FPI, $/bu.

       XCRN = total corn production, mil. bu.

     CCCSTK = ending CCC-owned stocks of corn, mil. bu.

      APCRN = total area planted to corn, mil. acres

D23 = 1 in calendar quarters 2 and 3, 0 otherwise

D4 = 1 in calendar quarter 4, 0 otherwise

Qi = 1 in calendar quarter i, -1 in calendar quarter 3,
     0 otherwise (i = 1, 2, 4)

Although the government-controlled stocks variable in the estimation includes FOR stocks, in the No-FOR model simulations in the next section, only CCC-owned stocks appear as government-controlled.

For the remainder of the structural relationships of the model there was no prior evidence to suggest any behavioral change following introduction of the FOR, and hence, the processes determining these relationships are assumed to have been generated from a structurally homogeneous period.

Historical Simulation of the Policy Alternatives

With the FOR and No-FOR models representing the market structures of the corn-livestock sector under the FOR policy, and alternative CCC policy, respectively, deterministic simulations of each model are conducted to examine the behavior of the systems under similar sets of circumstances. Generated scenarios from the simulation passes for prices, carryover stocks, production and utilization of corn, and livestock price and production levels form the basis for evaluating the FOR program relative to the alternative storage policy.

To avoid the imposition of ad hoc provisions and rules reflecting the many components of the FOR, the simulation process begins in 1977IV, and proceeds through 1982III. This time frame is well-suited for the analysis

because it encompasses periods of both tight and depressed markets. In the simulation exercise, the provisions of FOR operation remain at their historical settings, with the exception that direct entry is allowed in all periods. The CCC loan rate, an important parameter in the No-FOR model, also remains at its historical value. All other policies characterizing the 1977-1982 period are taken as a given.

The simulation process itself is quite interactive when conducted in the framework of the management rules for the alternative policy outlined above. In the No-FOR model, the price vector for each crop year is first solved and "checked" before continuing to the next year. If specific policy actions are required based on the model's solution, these actions are imposed on the model, and the solution recomputed for the same year. If no action is necessary, the process continues to the next year and so on. In the FOR model, the process is much simpler, since the only management rule imposed on the solution reflects the dumping of FOR stocks on the market at prices above the call level. No judgmental inputs are introduced at any point in the solution of either model. Although interactive, the simulation process is entirely mechanical with the management rules for the respective policy options, and the actual exogenous variables conditioning the two models.

Outcomes generated from the simulation exercise for selected variables in the U.S. corn market are reported in Table 8.1. The levels of these variables under each option appear in the table, together with the percentage change under the FOR policy scheme. Because the structures of the two models differ only by the inclusion or absence of the FOR program,

Table 8.1. Levels of selected variables in the U.S corn market under the FOR and No-FOR policy options, 1977IV-1982III

| | Crop Year | | | | | | | | | | | | | | |
| | 1977/78 | | | 1978/79 | | | 1979/80 | | | 1980/81 | | | 1981/82 | | |
Variable	FOR	No-FOR	Percent[a] change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change
							- - - million bushels - - -								
Total utilization	6480	6503	-0.3	6866	7217	-4.9	7321	7690	-4.8	6798	6580	3.3	6950	7017	-1.0
Feed	4002	4020	-0.4	4168	4416	-5.6	4378	4587	-4.6	4007	3817	5.0	4162	4241	-1.9
FSI	587	586	0.2	597	624	-4.3	707	724	-2.3	731	700	4.4	798	809	-1.4
Exports	1891	1898	-0.4	2101	2177	-3.5	2236	2379	-6.0	2060	2063	-0.1	1990	1967	1.2
Total stocks	1027	1004	2.3	1244	866	43.6	1614	833	93.8	1289	681	89.3	2103	1437	47.0
Commercial	720	716	0.6	547	866	-36.8	469	833	-43.7	761	681	11.7	388	769	-49.5
CCC	13	288	---	99	0	---	256	0	---	138	0	---	202	688	---
FOR	294	0	---	598	0	---	889	0	---	391	0	---	1513	0	---
Production	6621	6621	0.0	7083	7080	0.0	7691	7657	0.4	6474	6427	0.7	7764	7773	-0.1
							- - - dollars per bushel - - -								
Farm price															
Mean	2.05	2.06	-0.5	2.46	2.12	16.0	2.53	2.28	11.0	2.99	3.38	-11.5	2.57	2.40	7.1
Std. dev.	0.37	0.35	---	0.33	0.30	---	0.38	0.42	---	0.35	0.18	---	0.16	0.19	---

[a]Percent change under FOR policy option, selected variables.

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variations in the simulated outcomes for the two options directly reflect the implications of the program. The implications of the FOR relative to the alternative program are discussed categorically below.

Corn stock effects

Expansion of carryover stocks has been posited as one of the fundamental objectives of the Farmer-Owned Reserve program. Large carryover stocks absorb the market impacts of external shocks, thus moderating price responses. Table 8.1 suggests that the program has been quite successful at achieving an increase in total stocks of corn over the period, 1977-1982. Under the FOR, average ending stocks of corn were 1455 million bushels, whereas under the alternative storage program, ending stocks averaged only 964 million bushels. The increase in total stocks in the FOR model occurred in spite of the fact that the level of commercial stocks was for the most part, reduced by FOR operations. Ending commercially-held stocks of corn under the FOR program averaged 577 million bushels, compared with 773 million bushels in the absence of the program. Logically, free stocks should be smaller in the presence of the FOR program, because of the larger substitution of government-controlled stocks for free stocks in the FOR model. A one dollar decrease in the price of corn, for example, initially increases free stocks in both models by 588 million bushels. However, the price induced expansion of reserve stocks by 483 million bushels subsequently displaces 171 million bushels of the increase in free stocks in the FOR model. Slightly larger ending commercial stocks in the FOR model in the 1977/78 and 1980/81 years are attributable to price differences between the two models.

Most of the expansion in total stock levels under the FOR is the direct result of the operations of the program. However, some of the disparity between stock levels in the two models reflects the operational rules for CCC stock accumulation. Adherence to the set of rules outline above resulted in zero CCC carryovers for three years of the five year period in the No-FOR model. Strong supply relative to demand in the 1977/78 year implied an equilibrium price below the $2.00 loan level. To clear the market at the loan level in the No-FOR model required the CCC to accumulate 288 million bushels of corn by yearend. However, because the assumed management rules of CCC-stock operations were to release stocks to the market as soon as price surpassed 115 percent of the loan, the entire 288 million bushels was placed back on the market in the third and fourth quarters of the 1978/79 year. Because the seasonally adjusted market price of corn in the No-FOR model remained above the CCC loan rate until 1981/82, the level of CCC-owned stocks remained at zero until then. By contrast, the release level for government held stocks in the FOR model, at 105 percent of the call level, was more than $0.70 higher than the release level in the No-FOR model. Since the role of CCC stocks in the FOR model was assumed to be that of a backup buffer stock, these inventories were only liquidated in periods of very high prices so as to avoid interference with normal FOR operations. Under the FOR, the market price exceeded the trigger level for CCC stock release only in the second quarter of the 1980/81 year.

Operationally, the Farmer-Owned Reserve program buffers sharp price movements by transferring the impact of market variations to stock level changes. Price enhancing shocks in the FOR model induce larger drawdowns in

total stocks while price depressing shocks result in larger accumulations. Variation measures reported in Table 8.2 support the supposition that FOR operations aimed at stabilizing prices through stock changes consequently destabilize total stock levels. The table also suggests, however, that as a result of the substitution of FOR stocks for commercial stocks, the FOR program reduces the variability of commercial stock levels.

Corn price effects

The Farmer-Owned Reserve program as mandated in 1977 was not specifically intended to function as a price supporting mechanism. However, depending on the relationship between the expected returns to participation and the current market price of program commodities, the program may enhance mean price levels directly by isolating larger quantities of grain from the market through stock accumulation. Intended or not, this apparently was the situation in U.S. corn markets over the five year period investigated. By virtue of its contribution to total stock levels, the FOR raised the average price of corn from the $2.45/bushel level prevailing in the absence of the program, to $2.52/bushel. Although increasing the average price of corn over the entire period, the implications of the program for average corn prices in a particular year critically depend on the characteristics of that year. As illustrated in Figure 8.1, prices in relatively lean crop years such as existed in 1980/81, were actually lower in the presence of the FOR program, whereas in periods of strong supply relative to demand, reserve placements supported price levels. Because of the dual stabilization focus implicit in the operating rules of the FOR, the program reduces prices in high price periods, and enhances prices in low price periods.

Table 8.2. Variation in corn stock levels under the FOR and No-FOR policy
options, 1977IV - 1982III

Variable	Average quarterly variation[a]	
	FOR	No-FOR
	- - - - million bushels - - - -	
Total stocks	467	368
Commercial stocks	227	251

[a]Computed as average standard deviation of stock levels per quarter
through the sample period.

Average corn prices in the 1977/78 year were slightly higher in the

absence of the FOR because of stock accumulations by the CCC necessary to

clear the market at the loan level. The accumulation of 288 million bushels

of corn by the CCC in 1977/78 acted to raise the average price of corn by

$0.12/bushel in the No-FOR model. However, in the 1978/79 and 1979/80

years, FOR stock expansion significantly raised average corn prices over

what would have existed in the absence of the program. With zero reserves

in the No-FOR model at the outset of the 1980/81 year, the average price of

corn climbed to $3.38/bushel. By contrast, the average corn price under the

FOR for 1980/81 year was only $2.99/bushel. As prices under the FOR

exceeded the $2.81 release level in the fall, and the $3.26 call level in

the winter quarter, 498 million bushels of reserve corn reentered the

market. To this amount was added 116 million bushels of CCC-owned corn,

released in the winter quarter by prices temporarily above the CCC trigger

level. In the No-FOR model, on the other hand, CCC-stocks were totally
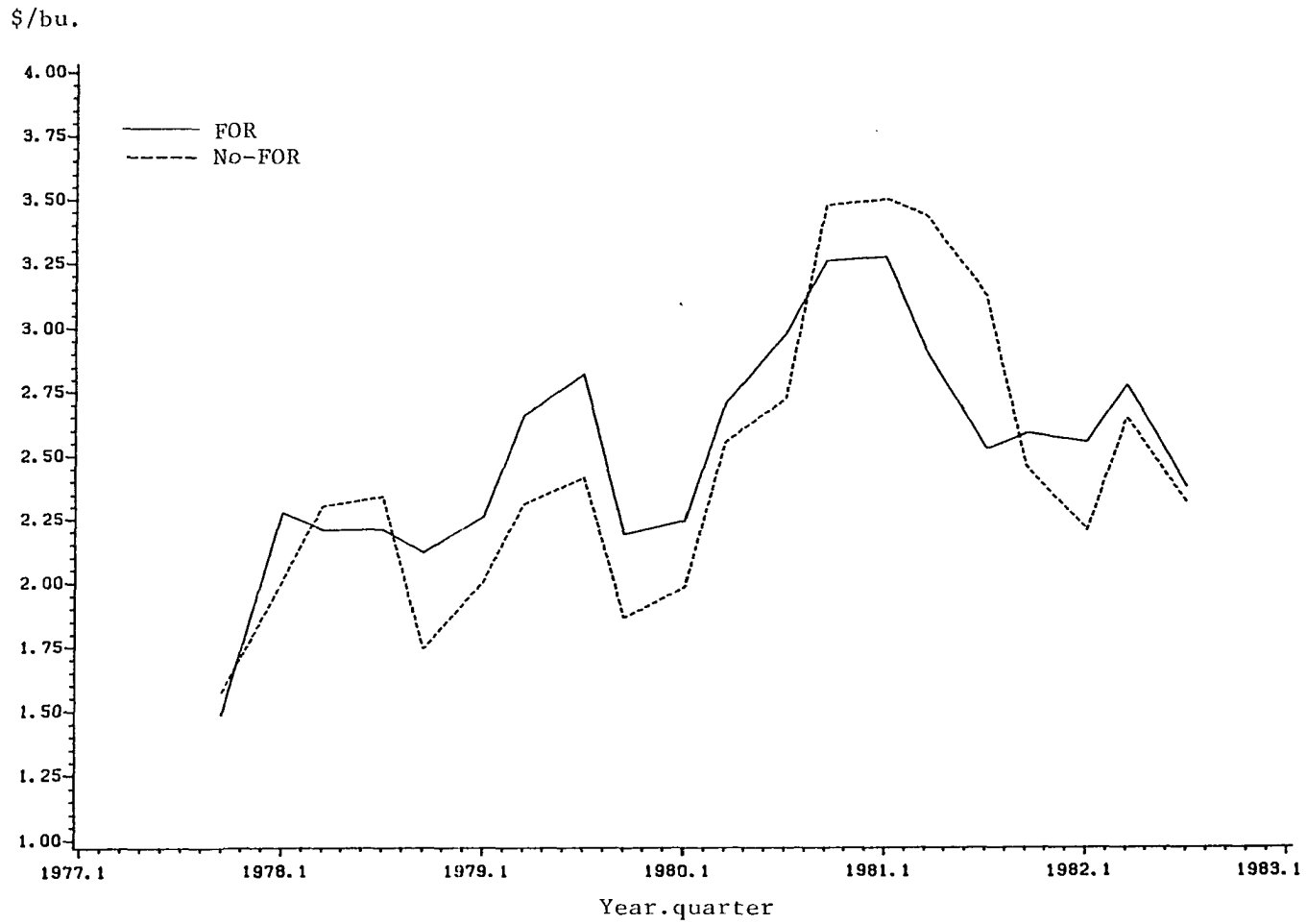
Figure 8.1. Farm price of corn under the FOR and No-FOR policy options

exhausted prior to the 1980/81 marketing year, leaving no reserves on hand
to contain upward price movements.

The short 1980/81 crop was followed by a record crop in 1981/82.
Prices in the absence of the FOR program responded quite sharply to the
record corn yields. CCC stocks increased to 688 million bushels by yearend
to support the $2.40 loan level. In the FOR model, reserve placements
absorbed a substantial amount of the new production, increasing by 1122
million bushels during the year. The increase in reserve placements in
1981/82 was to a large extent induced by the $2.55 loan level for the FOR
loans, which for the first time deviated from the regular CCC loan level.
Interestingly, the difference in average price levels under the two policies
in the 1981/82 year closely reflected the differing loan levels between the
two programs.

Probably the most .important aspect of the FOR program's performance is
its impact on the variation in corn prices over time. Together with
increasing carryover stock levels, the primary objective of FOR operation is
taken to be the stabilization of prices. Table 8.3 reports corn price
variation measures for both policy scenarios on seasonal and annual bases.

Based on the simulation results, the FOR appears to have significantly
decreased the year-to-year variation in U.S. corn prices over the period.
In the absence of the program, corn price variability throughout the
1977-1982 period would have increased 59 percent. The ability of the FOR to
moderate the severity of wide price swings is readily evident in Figure 8.1
earlier. The increase in annual price from 1979/80 to 1980/81, for example,
was $0.46/bushel in the FOR model compared with $1.08/bushel in the No-FOR

Table 8.3. Variation in corn prices under the FOR and No-FOR policy
options, 1977IV - 1982III

Periodicity	Corn price variation[a]	
	FOR	No-FOR
	- - - - dollars per bushel - - - -	
Annual	0.34	0.54
Seasonal	0.32	0.29

[a]Annual price variation was computed as the standard deviation of the
annual mean price levels around the period mean. Seasonal price variation
was computed as the average within year standard deviation in price.

model. From 1980/81 to 1981/82, FOR-influenced corn prices fell by

$0.42/bushel, whereas the price response in the absence of the FOR was

-$0.98/bushel.

While decreasing the annual variation in corn prices, the results of

the analysis suggest that the FOR exerted little impact on the seasonal, or

within year variation in prices. In three of the five years of the period,

the seasonal variation in corn prices was actually larger in the presence of

the reserve program. Moreover, a degree of stability in prices in the

No-FOR model was forfeited in the analysis because CCC stocks were zero for

the 1978 through 1980 crop years, and as a result unavailable to curtail the

generally rising prices of the period.

The rather minor influence of the FOR program on seasonal price

variation relative to the alternative CCC policy is, in part, attributable

to the characteristics of the respective policies. By virtue of its three

year participation period, the FOR program is essentially a long term

marketing aid. One might therefore assume that the operations of the program were geared primarily towards the reduction of prices between marketing years. In this context, an indicator of stability between years would constitute a more appropriate measure of the price stabilizing characteristics of the FOR program. Although not operated strictly as a buffer stock, the regular CCC loan program appears better suited to influence the marketing of grain, and thus, the variability of prices within a marketing year.

Corn utilization and production effects

The effects of the FOR program on corn utilization reflect the corn price responses and livestock sector adjustments induced by the program. Through the five year period corn prices under the FOR were increased by 3.2 percent. Lower prices in the absence of the program facilitated a larger movement of corn into the feed, FSI, and export market channels. Under the No-FOR option, the average amount of corn consumed per year was 7.01 billion bushels. With the FOR in operation, average corn consumption was 6.88 billion bushels, for a reduction of 1.7 percent. Feed, FSI, and export demands were reduced 1.8 percent, 2.0 percent, and 0.7 percent, respectively by the FOR over the first five years of its existence.

Interestingly, the analysis suggests that the FOR program reduced the variation in total marketings. This result is not implicit in the operations of the program, since FOR activity aimed at stabilizing prices do not necessarily stabilize marketings. The variation in marketings between the two policy strategies may be demonstrated to be crucially dependent on the sources of instability causing price movements. For example, increased

placement activity following a supply increase, tends to offset some of the downward potential for prices thereby reducing the rate of increase in demand in the FOR model relative to the No-FOR scenario. On the other hand, price moderating reserve activity following a demand decrease causes demand to fall off at a faster rate, implying greater variation in utilization under the FOR.

Nonetheless, the analysis indicates that the FOR did significantly reduce the variation in utilization over the period. On the basis of standard deviation, the year-to-year variation in total corn utilization was 330 million bushels with the FOR, and 487 million bushels in its absence.

Production of corn was affected to only a minor extent by the FOR program. On average the program increased the plantings, and hence, production of corn by less than one percent. Production in the presence of the FOR was only reduced below production without the program in the 1981/82 year, when no acreage programs were in existence, and plantings in the No-FOR model reflected the expected continuation of the $3.40/bushel prices that prevailed in 1980/81.

It should be noted that if anything, the production effects of the program may be biased downward in the analysis. If the reserve program reduced the risk, or more importantly the perceived risk of unintended price swings, the acreage response function may either have shifted up, or become more price inelastic in the post-1977 period reflecting the risk-averse nature of agricultural production decisions. This potential shift in the structure of the acreage relationship was not incorporated into the models,

but if present would have induced further increases in plantings in the FOR

model relative to the No-FOR model.

Livestock market effects

The livestock sector itself acts as a buffer mechanism with respect to

the feed grain markets (Offutt, 1984). Adjustments in the livestock sector

to corn market signals increase the long term elasticity of total corn

demand. Thus, the sector functions in a manner that complements the

operations of the FOR in the intermediate and long run.

In the short run given animal numbers, sectoral responses to corn price

movements depend on ration substitution possibilities, and production

flexibility in terms of animal slaughter weights. Long run responses in the

livestock sector depend on the manner in which the inventories adjust to

expected prices. Typically cattle respond the quickest to variation in

feeding costs and conditions, and hence policies affecting feed grain

markets, because potential slaughter animals may bypass the feedlot and

remain on roughage feeds. In the pork production sector, the slaughter of

breeding animals represents the only short term response, due to the fact

that the size of the finished animal and feeding patterns are not as

adjustable.

Levels of key variables in the livestock and poultry sector under the

FOR and alternative policy regime are reported in Table 8.4 for the period,

1978I-1982IV. Higher corn prices in the presence of the FOR for the first

three years of the period induced reductions in the respective livestock

inventories under the program relative to the alternative policy

(Figure 8.2).

Table 8.4. Levels of selected variables in the U.S. livestock-poultry sector under FOR and No-FOR policy options, 1978I-1982IV

| | 1978 | | | 1979 | | | 1980 | | | 1981 | | | 1982 | | |
Variable	FOR	No-FOR	Percent[a] change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change	FOR	No-FOR	Percent change
						- - thousand head - -										
Inventory																
Beef cows	37844	37830	0.0	38034	38077	-0.1	39403	39487	-0.2	38955	38885	0.2	37884	37672	0.6
Cattle on feed	10544	10691	-1.4	10802	11227	-3.8	10270	10446	-1.7	10392	10093	3.0	10913	11058	-1.3
Sows farrowing	13375	13381	-0.0	13929	13992	-0.5	13417	13610	-1.4	12198	12289	-0.7	11483	11358	1.1
						- - million pounds - -										
Production																
Fed beef	16457	16501	-0.3	16898	17188	-1.7	16738	17032	-1.7	16321	16136	1.1	16787	16788	-0.0
Pork	14026	14023	0.0	15429	15442	-0.1	15714	15846	-0.8	15194	15383	-1.2	14067	14008	0.4
Broilers	10057	10059	-0.0	10872	10930	-0.5	11493	11556	-0.5	11910	11856	0.4	12375	12360	0.1
						- - dollars per cwt. - -										
Farm prices																
Choice steers	53.72	53.51	0.4	65.39	64.30	1.7	63.53	62.40	1.8	63.19	63.95	-1.2	67.65	67.55	0.1
Feeder cattle	54.76	55.13	-0.7	72.17	72.51	-0.5	67.02	65.79	1.9	65.06	63.68	2.2	70.44	71.80	-1.9
Hogs	42.38	42.39	-0.0	43.77	43.53	0.6	43.42	42.13	3.1	47.23	45.67	3.4	60.05	60.85	-1.3
Broilers	25.71	25.73	-0.0	30.62	30.14	1.6	28.28	27.55	2.6	28.69	29.05	-1.2	24.11	24.35	-1.0

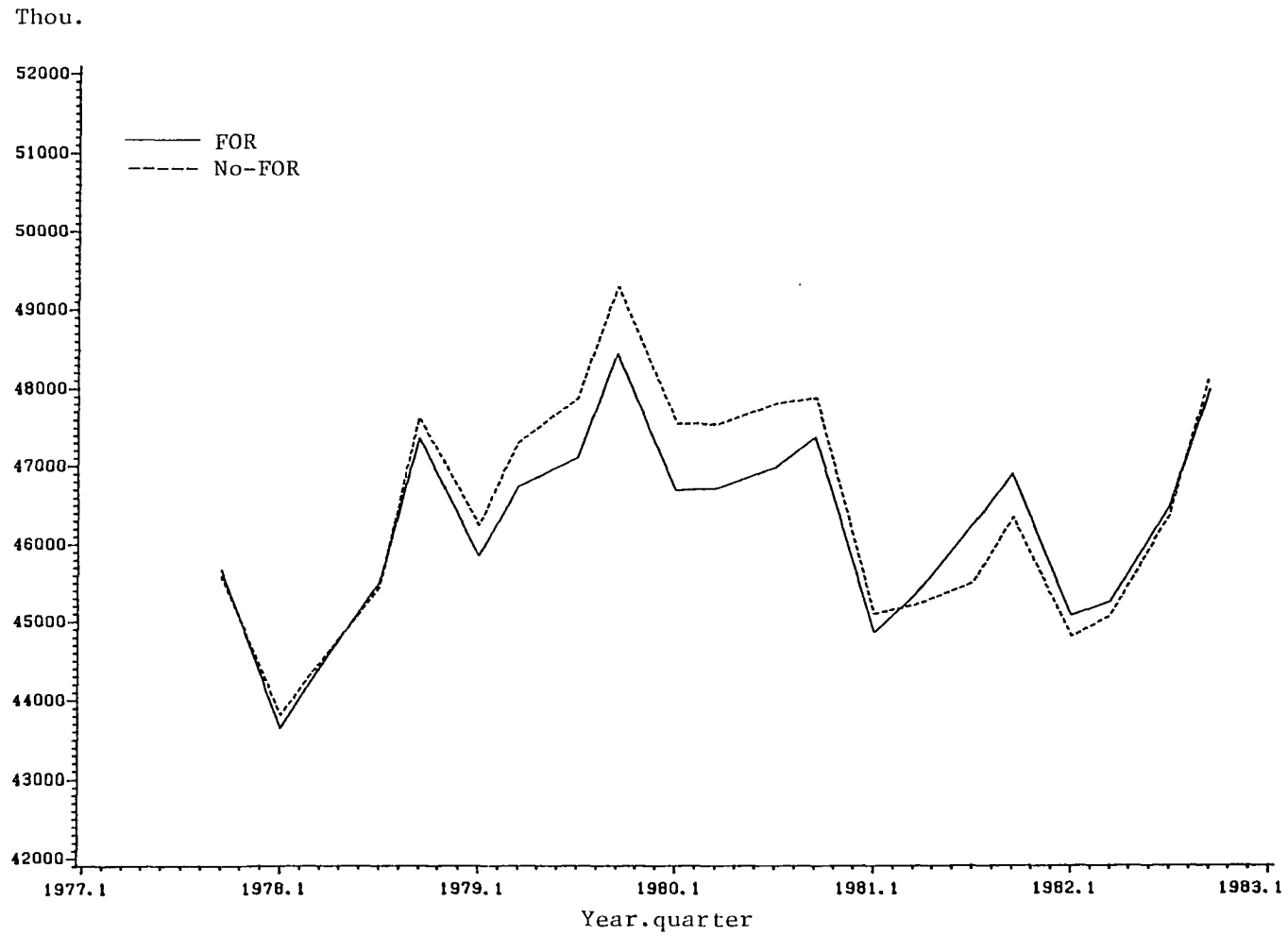[a]Percent change under FOR policy option.

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Figure 8.2.   Grain consuming animal units under the FOR and No-FOR policy options

The livestock market impacts of the FOR policy were relatively minor in 1978. Under FOR operation, the number of cattle on feed was reduced by 1.4 percent resulting in a 44.7 million pound reduction in the production of high quality beef for the year. The production of broiler meat similarly responded to higher corn prices under the FOR, while pork production was initially larger reflecting the increased culling of sows from breeding herds and the decreased retention of gilts. Although broiler and cattle prices were enhanced by the FOR in 1978, livestock and poultry prices as a whole were largely unchanged (Figure 8.3), due to transitory decreases in pork prices.[1] In 1979, placement of corn under FOR loan tightened the markets, raising the price of corn by $0.34/bushel. Poor feeding margins prompted reductions in all livestock inventory categories under FOR operation, resulting in a 1.7 percent decrease in the number of grain consuming animal units. The farm prices of choice steers, and broilers were increased 1.7 and 1.6 percent, respectively by the FOR in 1979, and the price of barrow and gilts by 0.5 percent. Because of technical constraints, the livestock production and price impacts of the higher FOR corn prices in 1979 became more evident in 1980. Total production of meat was reduced 1.1 percent by the FOR, which in turn, enhanced the farm prices of slaughter steers, hogs, and broilers by 1.8 percent, 2.9 percent, and 2.6 percent, respectively.

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[1]The index of livestock prices in the figure was computed as a weighted average of steer, hog, and broiler prices with 2.386, 1.406, and 0.656 constituting the weights on the prices, respectively. These weights were arrived at by deflating the prices of the commodities to 1957-1959 levels, and then weighting each group by its relative contribution to farm production receipts over the sample period.
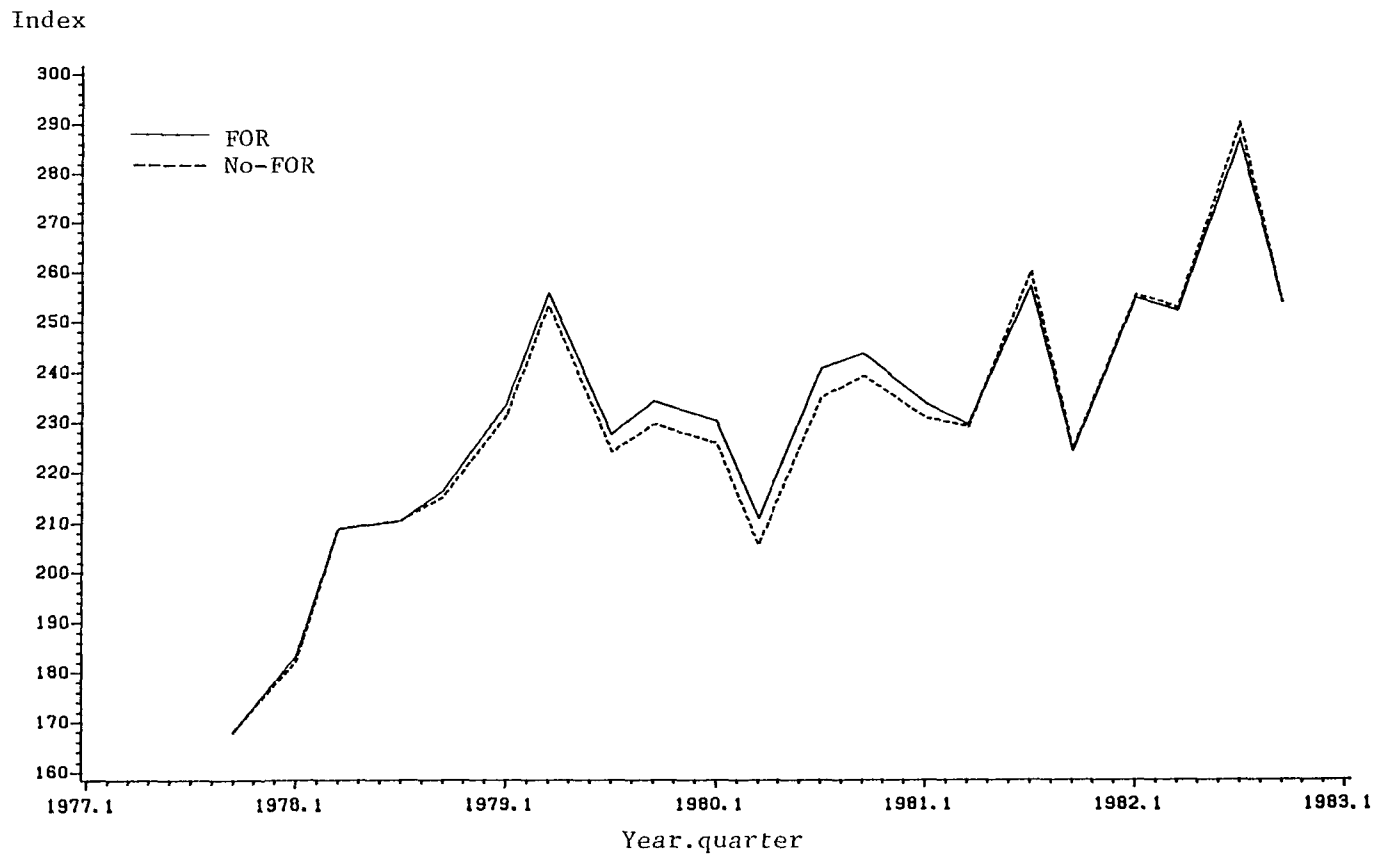
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Figure 8.3. Livestock prices under the FOR and No-FOR policy options

In 1981 and 1982, livestock market conditions under the two policies partially reversed. Corn prices under the alternative policy in 1981 soared to $3.12/bushel, exceeding prices under FOR operation by $0.30/bushel. High corn prices in both models encouraged a scaling back of feeding activities, however, the liquidation of inventory animals in the absence of the FOR program proceeded at a much more rapid rate. Larger production of fed beef and broilers under the FOR decreased the farm level prices of the two commodities by 1.2 and 1.3 percent respectively. Production of pork, on the other hand, was reduced by the FOR in 1981, reflecting the limited current period response of the pork sector to changing market conditions. Although corn prices were enhanced by heavy reserve activity in 1982, larger production of pork and broilers occurred under the program, reflecting the lower FOR corn prices in 1981. Livestock prices were slightly lower in 1982 under FOR operation, with the exception of slaughter cattle prices which were virtually unchanged.

In total, the FOR program increased the mean price level of all livestock commodities, but by relatively modest amounts (Table 8.5). The price of barrows and gilts was impacted the most, increasing by $0.51/cwt, or just over one percent. The influence of the program on livestock prices during the five year period primarily reflected higher corn prices under the FOR. By contrast, the FOR program had mixed implications for livestock price stabilization. Presumably the price bands in place for the feed grain reserve programs were established so as to impart acceptable levels of instability on the livestock sector. Stable feed grain prices implying stable feeding margins, reduce the risk of production commitments and

Table 8.5. Livestock and broiler mean price levels and variation under
FOR and No-FOR policy options, 1978I-1982IV

Commodity	Mean prices		Variation in prices			
			Seasonal[a]		Annual[b]	
	FOR	No-FOR	FOR	No-FOR	FOR	No-FOR
	- - - - - - - - - dollars per cwt. - - - - - - - - - -					
Choice steers	61.74	61.41	5.39	5.59	5.32	5.28
Feeder cattle	64.76	64.64	4.76	4.81	6.82	7.07
Barrows and gilts	46.01	45.50	5.45	5.52	7.32	7.92
Broilers	27.05	26.93	1.23	1.09	2.57	2.36

[a]Computed as the average within year standard deviation in price.
[b]Computed as the standard deviation of the annual mean price levels.

promote economic efficiency for reasons advanced earlier. Interestingly
enough, the analysis suggests that on an annual basis, choice steer and
broiler prices were actually more unstable under the FOR over the period.
However, in the case of choice steer prices, the difference was less than
one percent. On a seasonal basis, the program reduced the variability in
the farm prices of feeder and slaughter cattle, and barrows and gilts.

Conclusions

The analysis in this chapter suggests that the Farmer-Owned Reserve
program has profound implications for the markets of the corn-livestock
sector. Introduction of the program in 1977 induced a fundamental shift in
the structure, and hence, behavior of U.S. corn markets by creating another
price responsive component of total demand. Because corn is a crucial input

in the production of livestock and poultry, the program has important ramifications for these markets as well.

Over the period 1977IV-1982III, the analysis indicated that the FOR program exerted appreciable effects on both the mean price of corn, and the year-to-year variation in corn prices. The average annual price of corn for the period was $2.52/bushel in the presence of the FOR compared with an estimated $2.45/bushel in its absence. On the basis of standard deviation of annual prices about the period mean, the FOR was discovered to have decreased the variability of corn prices by $0.21/bushel. Specifically, the dual focus on price stabilization implicit in the reserve program's provisions enabled the FOR to significantly moderate the potential magnitude of price swings during the first five years of its existence. Relative to the alternative policy, the FOR program enhanced prices in surplus years, while curtailing prices in tight years.

The FOR directly influenced the structure of U.S. corn markets through its impact on stockholding behavior. On average, total ending stocks of corn were increased almost 500 million bushels by reserve operations over the period. Free stocks, on the other hand, were reduced by the FOR but the reduction was more than offset by larger reserve levels. Higher corn prices under the FOR induced small increases in the area planted to corn, with the production of corn averaging 18 million bushels more per year under the FOR than the alternative policy assumed in the analysis.

The corn price supporting characteristics of the FOR in its first three years brought about a contraction in livestock and poultry numbers and production relative to what would have prevailed in the absence of the

program. The analysis indicated a one-half to one percent reduction in the
production of red meat and poultry under the FOR in 1978-1980, with roughly
a two percent corresponding increase in the farm prices of the commodities
during the period. In 1981 and 1982, however, livestock and poultry prices
were decreased by the FOR program. Livestock numbers in the absence of the
program would have been sharply cut back, in response to estimated corn
prices as high as $3.49/bushel in 1981. With the FOR in operation, the
release of reserve grain during the period held prices to less than
$3.25/bushel. As a result, the number of animals on feed at the end of 1981
was 553 thousand higher under FOR operation. Although livestock and poultry
prices were decreased by FOR operations in the last two years of the period,
as a whole the operations of the program enhanced the farm prices of the
commodities from 1978-1982.

For the most part, the results of the analysis are consistent with the
findings reported in other evaluations of the Farmer-Owned Reserve program.
The $0.07/bushel estimated increase in corn prices attributed to the FOR was
exactly the conclusion reached in an evaluation of the program over the same
period by Salathe, Price, and Banker (1984), hereafter SPB. Meyers and Ryan
(1981), investigating the program's performance through 1980/81 detected
only a $0.01/bushel increase in corn prices under the FOR. The $0.21/bushel
reduction in corn price variability reported in this study compares
favorably with the $0.15/bushel reduction found by Meyers and Ryan. By
contrast, SPB concluded that the FOR brought about only a $0.01/bushel
reduction in corn price variability. The minor influence of the FOR on the
instability in prices in the SPB article was attributed to a narrower price

band under the alternative CCC policy assumed in their analysis. Because

SPB didn't report actual stock levels under the two policies, however, it is

difficult to ascertain stockholding behavior in their model, and the extent

to which government-owned stocks were used to enforce the price band of the

alternative policy. This behavior might indicate why in the short 1980/81

crop year, for example, their analysis revealed corn prices to be

$0.04/bushel lower in the absence of the FOR program, while this study and

the Meyers and Ryan work suggests prices were $0.38/bushel, and $0.21/bushel

higher, respectively, in the absence of the FOR. With regard to the

stockholding impacts of the program, the analysis in this chapter concluded

that the FOR added an average 491 million bushels to total ending stocks of

corn over the five year period. This estimate is much larger than the 221

and 233 million bushel stock increases reported by SPB, and Meyers and Ryan,

respectively. Most of the discrepancy in the estimates is explained by zero

CCC carryovers for three years under the alternative policy assumed in this

study. All three studies detected positive, but small effects of the

reserve on corn production. In no case was total production of corn

enhanced by more than one percent. The largest impact of the program on

livestock prices in both the SPB analysis and this study, occurred with

respect to market hog prices, reflecting the sensitivity of sow farrowing

decisions to expected feeding conditions. In the SPB study, the price of

steers was 0.26 percent higher under FOR operation, hogs were 1.6 percent

higher, and broilers 1.0 percent higher over the 1978-1982 period. Steer,

hog, and broiler prices in this study were determined to be 0.5, 1.1, and

0.4 percent higher, respectively in the presence of the FOR for the period.

Although the overall period livestock price effects are similar, the prices of hogs and broilers were found by SPB to be higher in each year of the period, whereas the prices of the two commodities in this study were lower under the FOR 1981 and 1982, reflecting lower corn prices in the FOR model.

The desired scope of the problem undertaken in this study prevented a comprehensive evaluation of the Farmer-Owned Reserve program. Specifically, the objective of the study was to quantify the immediate and direct effects of the FOR and alternative storage policy on the markets of the corn-livestock sector. As a result, several relevant issues regarding the performance and feasibility of the program, as well as the prospects for its future were not addressed. Among the more important of these is the degree of budget exposure implicit in the respective programs. Although the model was not equipped to measure the costs of the two program options implemented in the analysis, some general observations regarding the costs of the programs do stand out. More than likely the costs of the FOR program would exceed, and perhaps significantly, the costs of the alternative CCC-based policy. Throughout the analysis the amount of corn under FOR loan was substantially greater than the amount under the price support loan of the alternative policy. Thus, direct government outlays for producer loans would be noticeably larger under the FOR, although for the most part, these program costs are potentially recoverable since the loan must be repaid or the grain forfeited to the CCC. In the event grain is forfeited to the CCC, the recovery of expenditures for storing, handling, and transporting this grain would occur in a shorter period of time under the alternative policy, in view of the release levels for CCC stocks for the two policies.

Nonrecoverable costs of the FOR program include primarily the interest subsidies on FOR loans, and the storage payments to FOR participants. These costs are offset to a small extent, however, by lower deficiency payments necessary under the FOR program.

The model employed in the analysis was also incapable of empirically measuring the effects of the two programs on net farm income. Salathe et al. (1984) demonstrated that the FOR program directly enhanced net farm income. The small reduction in livestock receipts under the FOR was determined to be more than offset by increased crop income in their work. Because the model in this study was not formulated to explain production expenses under the two policies, one cannot discriminate between the two policies on the basis of income effects. Nonetheless, the results do suggest that the program improved crop income. Specifically, total marketing receipts for corn were enhanced by the FOR for the five year period, to which is added the rather sizable 26.5¢/bushel storage payments to FOR participants for corn under loan. Under the alternative policy, smaller plantings imply some reduction in production costs, however, in all probability the cost savings would be more than offset by the loss of the storage subsidies available under the FOR alternative.

CHAPTER IX. SUMMARY

The Farmer-Owned Reserve program was created in 1977 as an outgrowth of widespread concern over the volatility in commodity markets of the mid-1970s. Instability in the U.S. grain economy had become particularly acute at the time, reflecting the increased level and variability of U.S. exports, the insulation of important foreign markets from world price fluctuations, and the reluctance of the United States to erect trade barriers to protect domestic markets.

Since its inception, the Farmer-Owned Reserve has become a primary grains policy instrument in the United States. Among the major agricultural policy instruments in operation, only the FOR influences the marketing of grain between crop years, and offers some protection against future shortages. However, because the reserve program is passively operated from the standpoint of central authority, it is also the most difficult to control of the policy programs, and likely the least understood. In its seven year history, stocks of grain under the program have become quite massive and variable. Carryover reserve stocks of corn, for example, fluctuated from less than five percent of total utilization to around forty percent of total utilization. These stocks became so large in 1982/83 that drastic measures were implemented to control the size and costs of the program.

A variety of objectives have been articulated for the Farmer-Owned Reserve. They include establishing and maintaining a system of price corridors for major agricultural commodities, enhancing farm commodity

prices and incomes, expanding the level of carryover stocks for program

commodities, and reducing farm commodity price and income variability.

Among these it is generally agreed, at the program's outset at least, that

the primary management objective of the reserve program was the reduction of

price variability. To improve the stability of prices, the program offers

incentives to eligible farm producers to either place grain in the reserve

or remove grain from the reserve, depending upon the relationship of the

market price to the price parameters of the program. For example, to

encourage producers to isolate stocks from the market in periods of low or

falling prices, the FOR offers up-front money in the form of a price support

loan, and advance storage subsidies. When prices are high, incentives are

activated to encourage the liquidation of FOR contracts, such that the

producer may freely market his reserve grain taking advantage of the high

prices. In this manner, the program maintains a dual focus on the

stabilization of prices. Low prices trigger incentives to lock-up grain,

while high prices trigger incentives to bring these quantities back on the

market.

The desired degree of price stability is implicit in the program's

provisions. The loan level, or price for acquiring stocks constitutes an

effective price floor for participants. Given adequate reserve stocks, the

release and call levels, at which penalties for continued storage of reserve

grain are selectively imposed, loosely form price ceilings. The settings

for these parameters, which comprise the price band, are particularly

slippery issues. Concessions to certain groups at the expense of others

will obviously bring about dissatisfaction with the program, as well as move the market price to the boundaries of the price band.

Implementation of the Farmer-Owned Reserve in 1977 represented a major intervention into the speculative grain stockholding activity of the private sector. The fundamental structure of commodity markets, and market behavior was altered with the introduction of the program. By virtue of its size and operations, the FOR has obvious and important implications, not only for the eligible crops, but for related crops and the livestock industry as well.

This study sought to examine the economic effects of the Farmer-Owned Reserve program on the markets of the U.S. corn-livestock sector. A comprehensive econometric approach was used to investigate the impacts of the reserve program on the sector for the period 1977-1982, relative to continuation of the pre-1977 storage policies. A quarterly modeling approach was employed because it increases the number of observations on FOR behavior, and permits an examination of the within year as well as between year effects of the program.

Over the first five years of the program, the analysis indicated that the FOR program exerted appreciable effects on both the mean price of corn, and the year-to-year variation in corn prices. Average annual corn prices in the presence of the FOR for the period were $0.07/bushel higher than those that would have prevailed in the absence of the program. On the basis of standard deviation of annual prices around the five year mean, the results suggested that the program decreased the variability of corn prices by $0.21/bushel. Relative to the alternative storage policy, the reserve program enhanced prices in surplus years, while moderating the upward

pressure on prices in tight years. The program also made a substantial

contribution towards the objective of expansion of carryover stock levels.

In spite of the fact that commercial stocks were reduced by FOR operation,

the program induced over a 490 million bushel increase in carryover corn

stocks over the period.

The Farmer-Owned Reserve exerted noticeable, although not large

effects on the U.S. livestock industry over the five year period. Livestock

markets are directly affected by corn market policies through the market for

feed. Reserve-induced higher corn prices resulted in small reductions in

livestock herds, and hence, production under the FOR relative to

continuation of the pre-1977 policies. Correspondingly, livestock prices

were increased by around one percent by the operations of the program.

Stability in year-to-year corn prices also imparted some stability in

livestock prices under the reserve program.

The empirical approach employed in the analysis was structured for the

expressed purpose of assessing the economic ramifications of the FOR program

on the corn-livestock sector. Limitations in the scope of the analysis, and

model size prevented a full investigation of the performance and feasibility

of the reserve program. Specifically, the model was incapable of

quantifying the implications of the program for net farm income and

government outlays. While no conclusive remarks can be made regarding these

effects, in all probability it was felt that the program enhanced net farm

income, but with greater budgetary exposure than would have prevailed in the

absence of the program. Expanded analyses would undoubtedly want to

consider in an explicit manner the consequences of the program in these

areas. Moreover, expanded analyses may want to consider several alternative

program specifications. If price stabilization is truly an objective for an

agricultural policy, such studies may feel the need to evaluate a variety of

program designs that could potentially be used to attain a reduction in

commodity price variation. In addition to the policies investigated above,

this might include a simple storage subsidy to encourage stockholding, or

perhaps even government ownership of a buffer stock. As opposed to a

passively operated farmer-held stock program, central ownership enables the

program authorities to precisely control the flow of grain in and out of the

buffer stock, however, it may be that the costs or complexities of such

programs severely limit their practicality.

The FOR offers eligible producers a viable marketing alternative. It

can potentially enhance farm prices while simultaneously decreasing the

variability in prices. However, the program must be managed with close

discretion and foresight. Strict use of the provisions of the program for

the enhancement of prices threatens to revive the well-known problems

associated with supporting prices above market clearing levels and the

resulting imbalance of program stocks, such as occurred in 1982-83. If

successfully managed, the program would not generate uncertainty in the

marketplace, but rather guide production and consumption decisions,

facilitating the efficient flow of resources. To do so, a strict and well

communicated set of rules must be articulated that allow for the orderly

accumulation and marketing of grain. Knowledge of key parameters

determining farmer response to the program's provisions, and resulting

market behavior given expected participation, will continue to be a major

constraint in eliciting the desired outcomes to the program.

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ACKNOWLEDGEMENTS

APPENDIX A.   PROVISIONS OF THE RESERVE PROGRAM FOR CORN

August 29, 1977	Announced creation of feed grain reserve (Reserve I)
	    a. three year contracts
	    b. storage payments of $.20/bushel
	    c. target of 17-19 million tons.

December 6, 1977	Announced that reserve was expanded to include the 1976 and 1977 crops.
February 8, 1978	Increased reserve storage payments to $.25/bushel.
March 29, 178	Interest rate on FOR loans waived after first year. Announced early entry of corn starting May 1.
April 30, 1978	Deadline for transferring 1976 crop into the reserve.
May 31, 1978	Deadline for obtaining a price support loan on 1977 crop.
July 29, 1978	Announced a 30 day extension in loan maturity dates. Also corn loan program was reopened for two months (to run through Sept. 29), but only for producers who wish to put their grain immediately into the reserve.
August 7, 1978	Announcement that 1978 crop under price support loan will be permitted to go direct into the reserve if it appears that the reserve goals will not be met from 1977 crops by October 1.
October 5, 1978	Announced that 1978 crop eligible for immediate entry into reserve.
November 24, 1978	1978 crop will not be accepted for immediate entry into the reserve after November 30.
June 19, 1979	Corn enters release status.
August 1, 1979	Release discontinued. Also, producers give option to extend loans for six months.
August 3, 1979	Reserve grain that has been called but not redeemed is eligible to reenter reserve if national average price falls below the release level.
October 3, 1979	Corn released for second time.

October 22, 1979	All 1979 grain and outstanding 1978 loan grain eligible for immediate entry into reserve.
November 30, 1979	Release discontinued.
January 7, 1980	Reserve II opened. Loan, release, and call levels increased. Producers given 90 days for settlement of called grain. Storage payments increased to $26.5/bushel. First year interest costs waived for first 512 million bushels.
January 23, 1980	Corn placed in reserve between October 22 and January 7 will be eligible for interest waiver after January 7.
April 15, 1980	Non-participant corn producers may place grain in reserve.
May 13, 1980	Corn non-participants given 30 more days to put grain in reserve.
July 11, 1980	Corn released for third time.
July 28, 1980	Reserve III opened. Loan, release, and call levels increased.
August 25, 1980	No further entries into Reserve II.
August 29, 1980	Corn in Reserve III released.
September 8, 1980	Conversion to Reserve III must be done before a reserve is called. Reserve I call period extended to 90 days.
October 31, 1980	Corn in Reserve I called.
December 3, 1980	Loan rates increased. Release and call unchanged. Interest charge waived.
December 30, 1980	Corn in Reserve II and III called. Producers may continue to place eligible corn into Reserve III through January 15, 1981.
February 6, 1981	Authorized 30 day extension on reserve and regular loan maturity with 15-1/4% interest to be charged after maturity date. Also settlement date on Reserve II and III extended to May 15, 1981.
April 16, 1981	Settlement date cancelled. Farmers no longer have to settle by May 15, but 15-1/4% interest charged after April 15.

July 23, 1981	Interest waiver repealed.
October 6, 1981	Reserve IV opened. Immediate entry of 1981 crop allowed. Call price terminated. Trigger levels raised. No ceiling on placements.
January 29, 1982	Corn under CCC loan eligible for immediate entry.
July 1, 1982	Corn permitted immediate entry into Reserve V.
July 28, 1982	Rotation period extended from 30 to 60 days.
October 8, 1982	Farm-stored reserve corn can be removed if it was in danger of going out of condition or it is replaced in 15 days.
March 28, 1983	Notice that PIK grain can be rotated through normal rotation provisions.
July 15, 1983	Reserve VI triggered for release.
July 26, 1983	Reserve V triggered for release.
September 1, 1983	Storage payments stopped. Interest started.
November 2, 1983	Reserve V will remain in release status for at least November and December. Reserve holders to earn storage for this period.

APPENDIX B. STRUCTURE OF THE MODEL AND

DATA DEFINITIONS

The stochastic equations of the model were presented and discussed in detail in Chapter VI. The structural model used in the simulation exercises and analysis in Chapters VII and VIII, however, contained a number of identities not reported in Chapter VI. To illustrate the relationships of the model, and for ease of reference, the equations of the complete model are presented in Table B.1 below. The variables appearing in the model are defined in Table B.2, together with the references for data obtained directly from published sources. Because some of the variables in the model were derived rather than obtained directly, a description of the derivation process is discussed in the final section of the appendix.

Unless otherwise indicated, the data sources are identified by the following abbreviations:

AGP — Agricultural Prices (USDA)
AGS — Agricultural Statistics (USDA)
CPR — Current Population Reports (U.S. Department of Commerce)
 EE — Employment and Earnings (U.S. Department of Labor)
FAC — Foreign Agriculture Circular (USDA)
FOO — Fats and Oils Outlook and Situation Report (USDA)
FOS — Feed Outlook and Situation Report (USDA)
FRB — Federal Reserve Bulletin (Board of Governors of the Federal Reserve System)
GLA — Monthly Grain Loan Activity Report (USDA)
IFS — International Financial Statistics (International Monetary Fund)
LMS — Livestock and Meat Statistics Annual Summary (USDA)
LPOS — Livestock and Poultry Outlook and Situation Report (USDA)
 LS — Livestock Slaughter Annual Summary (USDA)
MLR — Monthly Labor Review (U.S. Department of Labor)
PPI — Producer Prices and Price Indexes (U.S. Department of Labor)
SCB — Survey of Current Business (U.S. Department of Commerce)
WOS — Wheat Outlook and Situation (USDA)

Table B.1. The equations of the complete model

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Corn demand equations

Feed demand

1. QCRNFEED = 244.03 - 188.12*RPCRN - 47.80*Q4*RPCRN - 54.23*Q1*RPCRN
            (0.53)   (2.64)   (1.39)   (1.16)
                     [0.42]   [0.37]   [0.49]

    - 29.34*Q2*RPCRN + 0.0194*GCAU + 96.55*RPWHT + 450.82*Q4
    (0.64)   (2.40)   (2.96)   (5.61)
    [0.53]   [0.86]   [0.30]

    + 272.36*Q1 + 19.18*Q2
    (2.54)   (0.18)

    (S/M = 0.08, R-SQUARE = 0.96, DW = 2.05, 2SLS, 1971IV - 1982IV)

FSI demand

2. QCRNFSIC = 1.387 - 0.177*RCPCRN - 0.00029*RDPIC + 0.064*RCPWHT
             (4.36) (4.02)   (3.27)   (2.96)
                     [0.34]   [1.44]   [0.17]

    + 0.0094*T - 0.036*Q4 - 0.036*Q1 + 0.093*Q2
    (14.11)   (2.97)   (3.03)   (7.77)

    - 0.071*D79*Q4 - 0.131*D79*Q1 - 0.045*D79*Q2
    (3.39)   (5.86)   (2.08)

    (S/M = 0.05, R-SQUARE = 0.96, DW = 1.20, 2SLS, 1971IV - 1982IV)

Export demand

3. QCEXNURS = -1580.93 - 108.19*RXPCRN3 - 0.654*EXPCOMP + 18.74*AUEC9J
              (1.76)   (3.11)   (1.27)   (2.14)
                         [0.56]   [0.17]   [5.48]

    + 0.609*QCEXNURS$_{t-4}$ - 136.37*D781 + 132.66*D8034
    (3.74)   (2.81)   (2.62)

    + 1.38*Q4 - 21.12*Q1 + 39.64*Q2
    (0.08)   (0.79)   (1.48)

    (S/M = 0.16, R-SQUARE = 0.76, DW = 1.59, 2SLS, 1971IV - 1982IV)

Table B.1. (continued)

Commercial inventory demand

4. ICRN = 3932.46 - 588.20*RPCRN + 274.93*Q4*RPCRN - 285.76*Q1*RPCRN
          (4.99)   (6.87)   (1.69)   (2.05)
                   [0.49]   [0.13]   [0.61]

   - 266.07*Q2*RPCRN + 0.629*D4*XCRN - 0.354*FORSTK - 20.54*D23*APCRN
     (1.77)   (4.93)   (3.59)   (1.23)
     [1.10]   [0.81]   [0.09]   [1.38]

   + 105.32*DPRELS - 2146.47*Q4 + 1443.48*Q1 + 1515.63*Q2
     (1.12)   (1.75)   (1.63)   (1.67)

   (S/M = 0.07, R-SQUARE = 0.99, DW = 1.03, 2SLS, 1971IV - 1982IV)

Farmer-Owned Reserve placements

5. PLACE = -1318.75 - 482.68*PCRN + 992.44*PV - 0.0047*AVAIL
           (5.60)   (10.28)   (11.30)   (0.32)
                     [5.60]   [12.31]   [0.07]

   + 0.027*Q4*AVAIL + 0.049*Q1*AVAIL - 0.049*Q2*AVAIL
     (2.24)   (4.38)   (4.09)
     [0.29]   [0.47]   [1.92]

   - 302.14*D823
     (3.60)

   (S/M = 0.17, R-SQUARE = 0.98, DW = 2.89, 2SLS, 1979IV - 1982IV)

Farmer-Owned Reserve redemptions

6. REDEMP = 102.07 + 52.12*PCRN - 28.74*RV + 0.0114*FORSTK$_{t-1}$
            (1.58)   (2.11)   (0.81)   (0.47)
                     [0.64]   [0.33]   [0.03]

   + 332.30*DCD
     (35.56)

   (S/M = 0.03, R-SQUARE = 0.99, 2SLS, 1979III - 1982IV:
        redemption periods)

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Table B.1. (continued)

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Corn production equation

   7. APCRN = 46.27 + 11.01*[PCRNA/PSBA] + 5.53*RPSCRN − 24.22*RDPCRN
           (5.99) (1.68)   (2.40)   (7.73)
                    [0.05]   [0.11]   [0.05]

        + 0.277*APCRN$_{t-4}$
          (2.99)

        (S/M = 0.02, R-SQUARE = 0.96, DH = 0.31, OLS, 1966 − 1982)

Corn market identities

   8. QCRNFSIC = QCRNFSI/USPOP

   9. FORSTK = FORSTK$_{t-1}$ + PLACE − REDEMP

  10. AVAIL = PART*(D4*XCRN + ICRN$_{t-1}$)

  11. PCRNA = 0.25*(PCRN + PCRN$_{t-1}$ + PCRN$_{t-2}$ + PCRN$_{t-3}$)

  12. QCRNEX = QCEXNURS + QCEXURS

  13. XCRN = 0.865*APCRN$_{t-2}$*YLDHA

  14. ICRN = D4*XCRN + ICRN$_{t-1}$ + FORSTK$_{t-1}$ + CCCSTK$_{t-1}$ − QCRNFEED
            − QCRNFSI − QCRNEX − FORSTK − CCCSTK

  15. RPCRN = (PCRN/FPI)*100

  16. RCPCRN = (PCRN/CBPI)*100

  17. RXPCRN3 = 0.333*[PCRN/DSDR + (PCRN/DSDR)$_{t-1}$ + (PCRN/DSDR)$_{t-2}$]

  18. GCAU = 1.665*COF + 0.23*(PIGCRP + PIGCRP$_{t-1}$ + SOWF + SOWF$_{t-1}$)
           + 2.29*XBRL + 1.05*DYCWS

Table B.1. (continued)

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Livestock and broiler production equations

Beef cow inventories

19. $BFCWS = -3501.6 + 0.889*BFCWS_{t-4} + 163.77*RPFDRSA_{t-4}$
    (1.37)   (16.15)   (11.26)
                    [0.21]

    $- 28.76*INTPR$
      (0.77)
      [0.01]

    (S/M = 0.01, R-SQUARE = 0.97, DH = 1.21, OLS, 1969-1983)

Feeder calf price

20. $RPFDRS = 15.025 + 0.840*RPFBF + 0.626*RPFBF_{t-1} - 5.460*RPCRN$
    (0.99)   (3.65)   (2.59)   (3.32)
           [0.83]   [0.62]   [0.25]

    $- 0.00062*BFCWS_{t-2} - 0.337*Q4 + 2.091*Q1 + 0.087*Q2$
      (1.76)   (0.28)   (1.90)   (0.07)
      [0.50]

    (S/M = 0.08, R-SQUARE = 0.89, DW = 0.54, 2SLS, 1971IV - 1982IV)

Cattle on feed

21. $COF = -963.74 + 33.084*[RPFBF - 10.68*[1.705*RPCRN$
    (0.46)   (3.00)
                 [0.17]   [0.14]

    $+ 0.0023*RPSBM]] + 0.772*COF_{t-1} + 0.0818*NETCLF + 1287.82*Q4$
                  (9.42)   (1.50)   (9.65)
         [0.01]   [0.31]

    $- 655.67*Q1 - 465.80*Q2$
      (4.25)   (3.47)

    (S/M = 0.05, R-SQUARE = 0.85, DW = 2.24, 2SLS, 1971IV - 1982IV)

Table B.1. (continued)

Production of fed beef

22. $XFBF = 2389.43 + 0.178*COF_{t-1} + 6.078*[RPFBF - 10.68*[1.705*RPCRN$
$\qquad$ (8.90) $\qquad$ (6.24) $\qquad$ (3.06)
$\qquad\qquad\qquad$ [0.42] $\qquad\qquad$ [0.07] $\qquad\qquad\qquad$ [0.06]

$\quad + 0.0023*RPSBM]] - 440.34*D7323 - 569.49*D7534 + 46.07*Q4$
$\qquad\qquad\qquad$ (3.58) $\qquad\qquad$ (5.24) $\qquad\qquad$ (1.20)
$\qquad$ [0.01]

$\quad - 4.41*Q1 - 76.91*Q2$
$\quad\;\;$ (0.09) $\quad$ (1.96)

(S/M = 0.03, R-SQUARE = 0.82, DW = 1.96, 2SLS, 1971IV - 1982IV)

Sows farrowing

23. $SOWF = -276.91 + 8.69*RPPK_{t-2} - 61.45*RPCRN_{t-2}$
$\qquad\qquad$ (0.70) $\quad$ (2.21) $\qquad$ (1.08)
$\qquad\qquad\qquad\qquad$ [0.12] $\qquad\quad$ [0.04]

$\quad + 0.496*[SOWF_{t-1} + SOWF_{t-2}] - 0.064*Q4*[SOWF_{t-1} + SOWF_{t-2}]$
$\quad\;\;$ (10.07) $\qquad\qquad\qquad\qquad\qquad$ (8.25)

$\quad - 0.063*Q1*[SOWF_{t-1} + SOWF_{t-2}] + 0.155*Q2*[SOWF_{t-1} + SOWF_{t-2}]$
$\quad\;\;$ (7.78) $\qquad\qquad\qquad\qquad\qquad$ (16.99)

$\quad + 234.23*D7783*Q4 + 62.75*D7783*Q1 - 497.58*D7783*Q2$
$\quad\;\;$ (3.68) $\qquad\qquad\quad$ (0.95) $\qquad\qquad$ (7.53)

$\quad - 28.23*INTPR + 9.87*T$
$\quad\;\;$ (2.04) $\qquad\quad$ (1.86)

(S/M = 0.04, R-SQUARE = 0.94, DH = 0.67, OLS, 1971IV -1983I)

Barrow and gilt slaughter

24. $BGSLT = 2673.28 + 0.646*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$
$\qquad\qquad$ (1.76) $\qquad$ (12.18)
$\qquad\qquad\qquad\qquad$ [0.79]

$\quad - 0.014*Q4*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$
$\quad\;\;$ (1.57)
$\quad\;\;$ [0.8]

Table B.1. (continued)

$$- 0.017*Q1*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$(2.09)$$
$$[0.80]$$

$$+ 0.014*Q2*[0.75*PIGCRP_{t-2} + 0.25*PIGCRP_{t-3}]$$
$$(1.72)$$
$$[0.79]$$

$$+ 42.70*T - 128.85*RPCRN_{t-1} - 1647.31*D7323$$
$$(4.70) \quad (0.56) \quad (2.18)$$

(S/M = 0.04, R-SQUARE = 0.91, DW = 1.65, OLS, 1971IV -1983I)

Sow slaughter

25. $$SOWSLT = -267.07 - 6.35*RPPK_{t-1} + 132.33*RPCRN_{t-1}$$
$$(0.93) \quad (2.71) \quad (4.39)$$
$$[0.24] \quad [0.26]$$

$$+ 0.213*[SOWF_{t-1} + SOWF_{t-2}] + 0.007*Q4*[SOWF_{t-1} + SOWF_{t-2}]$$
$$(6.26) \quad (1.46)$$
$$[1.20] \quad [1.19]$$

$$- 0.017*Q1*[SOWF_{t-1} + SOWF_{t-2}] - 0.003*Q2*[SOWF_{t-1} + SOWF_{t-2}]$$
$$(4.04) \quad (0.55)$$
$$[1.24] \quad [1.24]$$

(S/M = 0.09, R-SQUARE = 0.81, DW = 1.23, OLS, 1971IV - 1983I)

Pork production

26. $$XPK = -95.02 + 0.186*BGSLT + 0.224*SOWSLT + 23.46*Q4 - 14.02*Q1$$
$$(1.76) \quad (36.98) \quad (4.87) \quad (2.36) \quad (1.23)$$
$$[0.97] \quad [0.07]$$

$$+ 16.15*Q2 - 1.46*T$$
$$(1.51) \quad (2.65)$$

(S/M = 0.01, R-SQUARE = 0.99, DW = 0.78, 2SLS, 1971IV - 1983I)

Table B.1. (continued)

Broiler production

27. $XBRL = -62.84 + 9.48*RPBRL_{t-1} - 31.15*RPCRN_{t-1} + 2.55*LPROD$
    (0.27 (2.80)   (1.66)   (2.06)
          [0.09]   [0.03]   [0.12]

    $+ 0.854*XBRL_{t-1} - 179.19*Q4 + 20.29*Q1 + 182.71*Q2$
      (7.08)   (9.93)   (1.00)   (11.05)

    (S/M = 0.02, R-SQUARE = 0.99, DH = 0.03, OLS, 1971IV - 1983I)

Livestock and broiler production identities

28. $NETFDR = BFCWS_{t-2} - SCTOT$

29. $PIGCRP = SOWF*PIGSLITR$

30. $RPFDRS = (PFDRS/FPI)*100$

31. $RPFDRSA = 0.25*(RPFDRS + RPFDRS_{t-1} + RPFDRS_{t-2} + RPFDRS_{t-3})$

32. $RPFBF = (PFBF/FPI)*100$

33. $RPPK = (PPK/FPI)*100$

34. $RPBRL = (PBRL/FPI)*100$

Retail meat demand equations

Retail choice beef demand

35. $QTBFC = 11.71 - 0.196*RPRCF + 0.128*RPRGBF + 0.022*RPRPK$
            (3.81) (5.95)   (3.53)   (1.34)
                   [1.15]   [0.45]   [0.10]

    $- 0.009*RPRBRL + 0.0054*RDPIC - 1.697*D7323 - 0.095*T - 0.215*Q4$
      (0.21)   (5.36)   (3.36)   (7.07)   (1.75)
      [0.02]   [1.10]

    $- 0.118*Q1 + 0.021*Q2$
      (0.99)   (0.17)

    (S/M = 0.03, R-SQUARE = 0.87, DW = 1.41, 2SLS, 1971IV - 1983I)

Table B.1. (continued)

Retail pork demand

36. QPKC = 23.95 + 0.011*RPRCBF + 0.093*RPRGBF - 0.165*RPRPK
         (11.64) (0.55)   (4.09)   (15.39)
                 [0.06]   [0.32]   [0.71]

    - 0.008*RPRBL - 0.0003*RDPIC - 0.042*T + 0.875*Q4 - 0.016*Q1
      (0.34)   (0.42)   (5.17)   (9.75)   (0.19)
      [0.02]   [0.06]

    - 0.454*Q2
      (5.05)

    (S/M = 0.02, R-SQUARE = 0.97, DW = 1.26, 2SLS, 1971IV - 1983I)

Retail broiler demand

37. QBRLC = 4.679 - 0.016*RPRCBF + 0.071*RPRGBF + 0.020*RPRPK
          (2.65) (0.96)   (3.54)   (1.64)
                  [0.14]   [0.37]   [0.13]

    - 0.129*RPRBRL + 0.0013*RDPIC + 0.061*T - 0.619*Q4 - 0.348*Q1
      (4.26)   (2.05)   (8.04)   (7.52)   (4.81)
      [0.41]   [0.40]

    + 0.471*Q2
      (6.15)

    (S/M = 0.02, R-SQUARE = 0.96, DW = 1.32, 2SLS, 1971IV - 1983I)

Retail meat demand identities

38. QTBFC = [0.77*(XFBF + XNBF) - BFEX]/USPOP

39. QPKC = [XPK - (PKSTK - $PKSTK_{t-1}$) + PKM - PKEX]/USPOP

40. QBRLC = [XBRL - (BRLSTK - $BRLSTK_{t-1}$) - BRLEX]/USPOP

41. RPRCBF = (PRCBF/CPI)*100

42. RPRPK = (PRPK/CPI)*100

43. RPRBRL = (PRBRL/CPI)*100

Table B.1. (continued)

Farm-retail price margin equations

Fed beef margin

44. MFBF = -13.349 + 0.712*PFBF + 1.015*PFBF$_{t-1}$ + 10.039*WHMP
        (4.89)   (2.78)   (5.08)   (12.52)
                 [0.28]   [0.40]   [0.52]

    - 0.788*BPAB - 0.72*Q4 + 2.119*Q1 - 0.160*Q2
      (2.70)   (0.63)   (2.12)   (0.13)
      [0.09]

    (S/M = 0.03, R-SQUARE = 0.99, DW = 1.37, 2SLS, 1971IV - 1983I)

Pork margin

45. MPK = -3.858 + 0.198*PPK + 0.842*PPK$_{t-1}$ + 7.753*WHMP
         (1.52)   (1.60)   (9.61)   (21.33)
                  [0.09]   [0.40]   [0.59]

    - 0.456*BPAP - 0.230*Q4 + 1.269*Q1 - 1.870*Q2
      (0.73)   (0.28)   (1.72)   (2.46)
      [0.03]

    (S/M = 0.03, R-SQUARE = 0.98, DW = 1.51, 2SLS, 1971IV - 1983I)

Broiler margin

46. MBRL = 8.862 + 0.522*PBRL + 0.248*PBRL$_{t-1}$ + 3.013*WHPD
          (7.43)   (3.72)   (1.76)   (10.09)
                   [0.33]   [0.16]   [0.28]

    + 0.491*Q4 - 0.035*Q1 - 0.823*Q2
      (0.94)   (0.09)   (2.48)

    (S/M = 0.03, R-SQUARE = 0.95, DW = 1.99, 2SLS, 1971IV - 1983I)

Farm-retail margin identities

47. MFBF = PRCBF - PFBF

48. MPK = PRPK - PPK

49. MBRL = PRBRL - PBRL

Table B.2. Definitions and sources of data appearing in the model

Variable	Definition	Units	Source
Endogenous variables			
APCRN	area planted to corn, U.S.	mil. acres	FOS
AVAIL	total quantity of corn eligible for placement into Farmer-Owned Reserve Program	mil. bu.	derived
BFCWS	inventory of beef cows and heifers that have calved, end of period, annual series	thou. hd.	LMS
BGSLT	barrow and gilt slaughter under federal inspection	thou. hd.	LMS
COF	cattle on feed, 13 states	thou. hd.	LPOS
FORSTK	Farmer-Owned Reserve stocks of corn, end of period	mil. bu.	GLA
GCAU	grain consuming animal units, end of period	thou.	derived
ICRN	commercial stocks of corn, end of period, adjusted to calendar quantities	mil. bu.	derived
MBRL	farm-retail price margin for broilers	¢/lb.	derived
MFBF	farm-retail price margin for choice beef	¢/lb.	derived
MPK	farm-retail price margin for pork	¢/lb.	derived
NETFDR	number of calves on farms proxy	thou. hd.	derived
PBRL	farm price of young chickens, liveweight	¢/lb.	LPOS
PCRN	average corn price received by farmers, calendar quarters	$/bu.	FOS
PCRNA	four quarter moving average of corn prices (PCRN)	$/bu.	derived
PFBF	Omaha price of choice slaughter steers, 900-1100 lbs.	$/cwt.	LPOS

Table B.2. (continued)

Variable	Definition	Units	Source
PFDRS	feeder steer price, Kansas City, all weights and grades	$/cwt.	LMS
PIGCRP	pig crop, U.S. Dec.-Feb., Mar.-May, Jun.-Aug., Sept.-Nov. quarters	thou. hd.	LMS
PLACE	total placements of corn into Farmer-Owned Reserve program	mil. bu.	GLA
PPK	barrow and gilt price, 7 markets	$/cwt.	LPOS
PRBRL	retail price of young chickens, RTC, 4 region average	¢/lb.	LPOS
PRCBF	retail price of choice beef	¢/lb.	LPOS
PRPK	retail price of pork	¢/lb.	LPOS
QBRLC	per capita consumption of young chicken, U.S., RTC weight	lbs.	derived
QCEXNURS	U.S. corn exports, all destinations except USSR	mil. bu.	FAC
QCRNEX	total U.S. exports of corn, adjusted to calendar quarters	mil. bu.	derived
QCRNFEED	domestic corn feed use, adjusted to calendar quarters	mil. bu.	derived
QCRNFSI	domestic corn food, seed, and industrial use, adjusted to calendar quarters	mil. bu.	derived
QCRNFSIC	per capita domestic corn food, seed, and industrial use	bu.	derived
QPKC	per capita consumption of commercially produced pork, U.S.	lbs.	derived
QTBFC	per capita consumption of table quality beef, U.S.	lbs.	derived
RCPCRN	average corn price received by farmers deflated by CBPI	$/bu.	derived

Table B.2. (continued)

Variable	Definition	Units	Source
REDEMP	total redemptions of corn from Farmer-Owned Reserve program	mil. bu.	GLA
RPBRL	farm price of young chickens (PBRL) deflated by FPI	¢/lb.	derived
RPCRN	average corn price received by farmers (PCRN) deflated by FPI	$/bu.	derived
RPFBF	Omaha choice slaughter steer price (PFBF) deflated by FPI	$/cwt.	derived
RPFDS	Kansas City feeder steer price (PFDRS) deflated by FPI	$/cwt.	derived
RPFDRSA	four quarter moving average of deflated feeder steer prices (RPFDRS)	$/cwt.	derived
RPPK	barrow and gilt price, 7 markets (PPK) deflated by FPI	$/cwt.	derived
RPRBRL	retail price of young chickens(PRBRL) deflated by CPI	¢/lb.	derived
RPRCBF	retail price of choice beef (PRCBF) deflated by CPI	¢/lb.	derived
RPRPK	retail price of pork (PRPK) deflated by CPI	¢/lb.	derived
RXPCRN3	three quarter moving average of corn prices deflated by DSDR	$/bu.	derived
SOWF	sows farrowed, U.S., Dec.-Feb., Mar.-May, Jun.-Aug., Sept.-Nov. quarters	thou. hd.	LMS
SOWSLT	sow slaughter under federal inspection	thou. hd.	LMS
XBRL	total production of broiler meat, RTC weight	mil. lbs.	LPOS
XCRN	total annual production of corn	mil. bu.	FOS

Table B.2. (continued)

Variable	Definition	Units	Source
XFBF	total production of fed steer and heifer beef, carcass weight	mil. lbs.	derived
XPK	commercial production of pork, carcass weight	mil. lbs.	LPOS

Exogenous variables

AUEC9J	three quarter moving average of animal units in EC-9 countries and Japan	thou.	derived
BFEX	exports and shipments of beef, carcass weight	mil. lbs.	LPOS
BPAB	beef by-product allowance (carcass plus farm)	¢/lb.	LPOS
BPAP	pork by-product allowance	¢/lb.	LPOS
BRLEX	exports and shipments of young chickens	mil. lbs.	LPOS
BRLSTK	young chicken ending stocks	mil. lbs.	LPOS
CBPI	producer price index, cereal and bakery products, 1967=100	index	PPI
CCCSTK	CCC-owned stocks of corn, end of period, adjusted to calendar quarters	mil. bu.	derived
CPI	consumer price index, all items, 1967=100	index	SCB
DSDR	U.S. dollars per SDR, average per period	$	IFS
DYCWS	inventory of dairy cows and heifers that have calved, end of period, annual series interpolated to quarterly	thou. hd.	LMS
EXPCOMP	total corn exports of major competitors, interpolated to quarterly series	mil. bu.	derived
FPI	index of prices paid by farmers, all production items, 1977=100	index	AGP

Table B.2. (continued)

Variable	Definition	Units	Source
INTPR	four quarter moving average of interest rates charged by banks on short term loans	percent	FRB
LPROD	index of labor productivity in poultry production, interpolated to quarterly series, 1977=100	index	AGS
PART	proportion of farmers in compliance with current acreage program provisions	decimal	FOS
PIGSLITR	pigs saved per litter, U.S. average	#/litter	derived
PKEX	exports and shipments of pork, carcass weight	mil. lbs.	LPOS
PKM	imports of pork, carcass weight	mil. lbs.	LPOS
PKSTK	cold storage stocks of pork, end of period	mil. lbs.	LPOS
PSBA	four quarter moving average of soybean prices received by farmers	$/bu.	derived
PV	summary variable of expected returns to participation in Farmer-Owned Reserve program	$/bu.	derived
QCEXNURS	U.S. exports of corn to USSR	mil. bu.	FAC
RCPWHT	average wheat price received by farmers deflated by CBPI	$/bu.	derived
RDPCRN	effective diversion payment for corn deflated by FPI	$/bu.	derived
RDPIC	per capita disposable personal income deflated by CPI	thou. $	derived
RPRGBF	retail price of ground beef deflated by CPI	¢/lb.	derived
RPSBM	soybean meal price, Decatur, 44 percent, deflated by FPI	$/ton	derived

Table B.2. (continued)

Variable	Definition	Units	Source
RPSCRN	effective support rate for corn deflated by FPI	$/bu.	derived
RPWHT	average wheat price received deflated by FPI	$/bu.	derived
RV	opportunity cost of current marketing of corn released from the Farmer-Owned Reserve program	$/bu.	derived
SCTOT	total commercial calf slaughter, current and previous quarter	thou. hd.	LPOS
T	time trend variable	integer	derived
USPOP	total U.S. population	mil.	CPR
WHMP	average earnings for production workers in meat packing	$/hr.	EE
WHPD	average earnings for production workers in poultry dressing	$/hr.	EE
XNBF	total production of nonfed steer and heifer beef	mil. lbs.	derived
YLDHA	average U.S. corn yield per harvested acre	bu.	FOS

Dummy variables

DCD	dummy variable for redemption period following FOR interest waiver, equals 1 in 1981II, 0 otherwise	0,1	
DPRELS	dummy variable for periods of reserve release price adjustment, equals 1 in 1980I, 1980III, 1981IV, 1982IV, 0 otherwise	0,1	
D4	1 in fourth calendar quarter, 0 otherwise	0,1	

Table B.2. (continued)

Variable	Definition	Units	Source
D23	1 in second and third calendar quarter, 0 otherwise	0,1	
D79	1 after 1979IV, 0 otherwise	0,1	
D781	1 in 1977IV and 1978I, 0 otherwise	0,1	
D823	1 in 1982III, 0 otherwise	0,1	
D7323	1 in 1973II, 1973III, 0 otherwise	0,1	
D7534	1 in 1975III, 1975IV, 0 otherwise	0,1	
D7783	1 after 1977I, 0 otherwise	0,1	
D8034	1 in 1980III, 1980IV, 0 otherwise	0,1	
Q1	dummy variable for quarter 1, equals 1 in calendar quarter 1, -1 in calendar quarter 3, 0 otherwise	-1,0,1	
Q2	dummy variable for quarter 2, equals 1 in calendar quarter 2, -1 in calendar quarter 3, 0 otherwise	-1,0,1	
Q4	dummy variable for quarter 4, equals 1 in calendar quarter 4, -1 in calendar quarter 3, 0 otherwise	-1,0,1	

Generation of the Derived Variables of the Model

Endogenous variables

AVAIL

Only those producers in compliance with the terms of the current year's acreage programs were eligible to place grain in the Farmer-Owned Reserve. If no such programs were in existence, PART = 1.0. The amount of eligible grain is thus estimated as:

$$AVAIL = PART*(D4*XCRN + ICRN_{t-1})$$

GCAU

According to Van Meir (1984) and Allen and Devers (1975), grain consuming animal units is equal to 1.5 times the number of cattle on feed plus 1.05 times the number of dairy cows on farms plus 0.23 times hogs held for market plus 0.00653 times broilers on feed. From the historical data, the number of cattle on feed in the U.S. was estimated at 111 percent of the number of cattle on feed in the thirteen quarterly reporting states. Similarly the historical data indicated that the average RTC weight per broiler was 2.85 pounds. Assuming then that broilers are on feed for a period of one quarter, and hogs two quarters, and converting broiler production to one thousand units for consistency, GCAU becomes:

$$GCAU = 1.11*(1.5)*COF + 0.23*(PIGCRP + PIGCRP_{t-1} + SOWF + SOWF_{t-1})$$
$$+ (1000/2.85)*XBRL + 1.05*DYCWS$$

or

$$GCAU = 1.665*COF + 0.23(PIGCRP + PIGCRP_{t-1} + SOWF + SOWF_{t-1})$$
$$+ 2.29*XBRL + 1.05*DYCWS$$

QCRNFEED, QCRNFSI, QCRNEX, ICRN, CCCSTK

USDA's crop year quarters for reporting data are October-December, January-March, April-May and June-September. Because the third and fourth quarters of the crop year are of unequal duration, the data in the study reported on this basis was adjusted to three month quarters for consistency. Although this approach may introduce some bias, it was felt preferable to retaining quarters of unequal duration.

The adjustments in corn utilization were:

If calendar quarter = 2 then

$$QCRNFEED = 1.5*QCRNFEED'$$
$$QCRNFSI = 1.5*QCRNFSI'$$
$$QCRNEX = 1.5*QCRNEX'$$

If calendar quarter = 3 then

$$QCRNFEED = QCRNFEED' - 0.5*QCRNFEED'_{t-1}$$
$$QCRNFSI = QCRNFSI' - 0.5*QCRNFSI'_{t-1}$$
$$QCRNEX = QCRNEX' - 0.5*QCRNEX'_{t-1}$$

If calendar quarter = 1 or 4 then

$$QCRNFEED = QCRNFEED'$$
$$QCRNFSI = QCRNFSI'$$
$$QCRNEX = QCRNEX'$$

where:

QCRNFEED', QCRNFSI', QCRNEX' denote original USDA reported data

For stock variables the adjustments were:

If calendar quarter = 2 then

$$CCCSTK = CCCSTK' + 0.5(CCCSTK' - CCCSTK'_{t-1})$$

$$ICRN = ICRN_{t-1} + CCCSTK_{t-1} + FORSTK_{t-1} - QCRNFEED$$
$$- QCRNFSI - QCRNEX - CCCSTK - FORSTK$$

If calendar quarter = 1 or 3 or 4 then

$$CCCSTK = CCCSTK'$$

$$ICRN = ICRN'$$

where:

ICRN', CCCSTK' denote original data

NETFDR

The number of calves on farms is proxied in the model as the lagged number of beef cows minus calf slaughter in the current and previous quarters:

$$NETFDR = BFCWS_{t-2} - SCTOT$$

XFBF

$$XFBF = [FCM39ST*FCDRWT]/1000$$

where:

FCM39ST = fed cattle marketed, 39 states, thou. hd.
(source: LMS)

FCDRWT = weighted average dress weight, steers and heifers under federal inspection; wts. = 2/3 for steers, 1/3 for heifers (source: LS)

Exogenous variables

AUEC9J

The number of animal units in the EC-9 countries and Japan was computed as a three quarter moving average of:

AUEC9J = 1.1*(CTEC9 + CTJP) + 0.23*(HGEC9 + HGJP)

where:

CTEC9 = total cattle numbers in the EC-9, thou. hd., interpolated from annual data to quarterly series (source: FAC)

CTJP = total cattle numbers in Japan, thou. hd., interpolated from annual data to quarterly series (source: FAC)

HGEC9 = total number of hogs in EC-9 countries, thou. hd., interpolated from annual data to quarterly series (source: FAC)

HGJP = total number of hogs in Japan, thou. hd., interpolated from annual data to quarterly series (source: FAC)

EXPCOMP ·

Major competing exporters of corn in the world market include Argentina, Thailand, and South Africa. Only annual export data are available for these countries, reported on the basis of their respective marketing year. These marketing years run as:

Country	Marketing year
Argentina	March/February
South Africa	May/April
Thailand	July/June

To align these periods with the quarterly model, it was assumed that the marketing years for Argentina and South Africa began with the second

calendar quarter, and for Thailand, the third calendar quarter. According to USDA (1972), 65 percent of all competitor exports take place in the first six months of their marketing year, and 35 percent in the last half of the year. These proportions were assumed in the study to be equally spread over the quarters in the first, and second half of the year respectively. Thus, the proportion of annual competitor exports by calendar quarter were established as:

| | Calendar quarter | | | |
Exporter	1	2	3	4
Argentina	0.175	0.325	0.325	0.175
South Africa	0.175	0.325	0.325	0.175
Thailand	0.175	0.175	0.325	0.325

Hence, quarterly exports of corn by the major competitors were calculated as:

EXCOMP = 0.039368*(W1*EXPARG + W2*EXPSA + W3*EXPTHAI)

where:

W1, W2, W3 = quarterly proportion of annual corn exports for Argentina, South Africa, and Thailand, respectively

EXPARG = annual corn exports of Argentina, Mar.-Feb. year, thou. metric tons (source: FAC)

EXPSA = annual corn exports of South Africa, May-Apr. year, thou. metric tons (source: FAC)

EXPTHAI = annual corn exports of Thailand, July-June year, thou. metric tons (source: FAC)

The factor 0.039368 converts thousand metric tons to million bushels.

PIGSLITR

PIGSLITR = PIGCRP/SOWF

PSBA

$$PSBA = 0.25*(PSB + PSB_{t-1} + PSB_{t-2} + PSB_{t-3}$$

where:

PSB = average soybean price received by farmers, $/bu.
(source: FOO)

PV

The expected returns to participation in the Farmer-Owned Reserve

program was defined in accordance with Equations 6.5 - 6.7. The formula is:

PV = max(PV1, PV2)

where:

$$PV1 = PLOAN + \frac{0.97*PEXP - (1 + CCCINT*YRINT)*PLOAN}{(1 + TBILL)^2}$$

$$+ SPMT - SCOST + \frac{SPMT - SCOST}{1 + TBILL}$$

$$PV2 = PLOAN + SPMT - SCOST + \frac{SPMT - SCOST}{1 + TBILL} + \frac{SPMT - SCOST}{(1 + TBILL)^2}$$

PLOAN = FOR loan level, $/bu.

PEXP = expected redemption price (calculated as average of PRELS and PCALL) $/bu.

PRELS = FOR release, or trigger level, $/bu.

PCALL = FOR call level, $/bu.

CCCINT = interest charge per annum on FOR loans

YRINT = number of years interest accrues on FOR loans

SPMT = FOR storage subsidy, ¢/bu./year

SCOST = on-farm cash storage costs (assumed 15 ¢/bu./year)

TBILL = rate of return on government-issued Treasury bills
(source: FRB)

Unless otherwise specified, the above data are reported in Burnstein and Langley (1985).

RCPWHT

RCPWHT = (PWHT/CBPI)*100

where:

PWHT = average wheat price received by farmers, $/bu.
(source: WOS)

RDPCRN

RDPCRN = (DPCRN/FPI)*100

where:

DPCRN = effective diversion payment for corn (source: University of Missouri Agricultural Modeling Group - Data Bank)

RDPIC

RDPIC = ((DPI/USPOP)*100000)/CPI

where:

DPI = U.S. disposable personal income, bil. $ (source: SCB)

RPRGBF

RPRGBF = (PRGBF/CPI)*100

where:

PRGBF = estimated retail price of ground beef, ¢/lb.

Because the USDA's series on retail ground beef prices was discontinued

in 1980, retail prices were estimated from the price index, CPUBVHA. The

formula used to calculate PRGBF converts the index with base 100 in 1967

into a series with an average price of 52.25¢ in 1967. The formula is:

PRGBF = 0.5225*CPUBVHA

where:

CPUBVHA = retail price index for "ground beef other than
          canned" (source: MLR)

RPSBM

RPSBM = (PSBM/FPI)*100

where:

PSBM = soybean meal price, 44 percent, Decatur, $/ton
       (source: MLR)

RPSCRN

RPSCRN = (PSCRN/FPI)*100

where:

PSCRN = effective support rate for corn, $/bu. (source:
        University of Missouri Agricultural Modeling
        Group - Data Bank)

RPWHT

RPWHT = (PWHT/FPI)*100

where:

PWHT = average wheat price received by farmers $/bu.
(source: WOS)

RV

The opportunity cost of a current cash sale after release was defined in accordance with Equation 6.11. The formula is:

$$RV = \frac{1.10*PRELS + (1 + CCCINT_{t-4}*YRINT_{t-4})*PLOAN_{t-4}*TBILL}{(1 + TBILL)}$$

The variables are defined in the PV formula above.

T

The trend variable begins in 1971, and is defined as 1 in 1971IV, 2 in 1972I, etc.

XNBF

XNBF = XBF - XFBF - XCWS - XBULLS

where:

XCWS = (CWKCNUS*CWKGAUS)/1000

XBULLS = (BLKCNS*BLKGAUS)/1000

XBF = commercial production of beef, mil. lbs. (source: LMS)

CWKCWS = commercial cow slaughter, thou. hd. (source: LS)

CWKGAUS = dress weight, cows under federal inspection, lbs.
(source: LS)

BLKCNUS = commercial bull and stag slaughter, thou. hd.
          (source: LS)

BLKGAUS = dress weight, bulls under federal inspection, lbs.
          (source: LS)