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The U.S. Feed Concentrate-Livestock Economy's Demand Structure, 1949-1959 (with Projections for 1960-70)

James B. Hassler

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The U. S. Feed Concentrate-Livestock Economy's Demand Structure, 1949-1959
(with Projections for 1960-70)

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Lincoln, Nebraska

Agricultural Experiment Stations of Illinois, Iowa, Michigan, Minnesota, Missouri, North Dakota, South Dakota, Nebraska, Wisconsin, Ohio, Kansas, Indiana, and Alaska.
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Definitions of variables (U. S. averages unless otherwise specified)

\[ X_1 = \text{Per capita beef and veal consumption per year (lbs.)} \]
\[ X_2 = \text{Per capita pork (excluding lard) consumption per year (lbs.)} \]
\[ X_3 = \text{Per capita chicken consumption per year (lbs.)} \]
\[ X_4 = \text{Per capita turkey consumption per year (lbs.)} \]
\[ X_5 = \text{Per capita egg consumption per year (doz.)} \]
\[ X_6 = \text{Per capita fluid milk and cream consumption per year (lbs. of milk equivalent)} \]
\[ X_7 = \text{Per capita manufactured dairy products consumption per year (lbs. of milk equivalent)} \]
\[ X_8 = \text{Per capita margarine consumption per year (lbs.)} \]
\[ X_9 = \text{Per capita disposable income per year (dollars)} \]
\[ X_{10} = \text{Wage rate for food distribution employees (dollars per hr.)} \]

\[ P_1 = \text{Retail beef price (cents per lb.)} \]
\[ P_2 = \text{Retail pork price (cents per lb.)} \]
\[ P_3 = \text{Retail broiler price (cents per lb.)} \]
\[ P_4 = \text{Retail egg price (cents per doz.)} \]
\[ P_5 = \text{Retail fluid milk and cream price (cents per lb. of milk equivalent)} \]
\[ P_6 = \text{Omaha "farm" price for choice beef cattle (cents per lb.)} \]
\[ P_7 = \text{Omaha "farm" price for choice hogs (cents per lb.)} \]
\[ P_8 = \text{"Farm" price for broilers (cents per lb.)} \]
\[ P_9 = \text{"Farm" price for turkeys (cents per lb.)} \]
\[ P_{10} = \text{"Farm" price for eggs (cents per doz.)} \]
\[ P_{11} = \text{"Farm" blend price for Grade A milk (cents per lb.)} \]
\[ P_{12} = \text{"Farm" price for manufacturing milk (cents per lb.)} \]
\[ N = \text{U. S. population including armed forces overseas (millions)} \]
\[ P_B = \text{"Farm" price for broiler growing mash (cents per lb.)} \]
\[ P_E = \text{"Farm" price for laying mash (cents per lb.)} \]
\[ P_D = \text{"Farm" price for dairy ration (cents per lb.)} \]
\[ P = \text{"Farm" price for concentrates based on corn (cents per lb.)} \]
\[ P_i = \text{Value productivity of concentrates in i\textsuperscript{th} use (cents per lb.)} \]
\[ Y_i = N X_i \]
\[ Q_0 = \text{Annual usage of feed concentrates other than by beef cattle, dairy cattle, broilers, hens, turkeys, and hogs (millions of lbs.)} \]
\[ Q = \text{Concentrates fed in i\textsuperscript{th} use per year (millions of lbs.)} \]
\[ Q_i = \text{Concentrates fed in i\textsuperscript{th} use per year (millions of lbs.)} \]
\[ Q = Q_0 + \sum_{i=1}^{7} Q_i \]
\[ t = \text{Time in years (1949 = 0)} \]
PREFACE

Several years ago, members of the NCM-19 Technical Committee on grain marketing research decided to do more detailed research on the spatial aspects of the livestock-feed economy that had been considered by K. Fox (Econometrica, October 1953, 547-566) and Fox and Taeuber (American Economic Review, September 1955, 584-608). The decision was to disaggregate this earlier work to increase the clarity and utility of the results. As a member of the Nebraska Agricultural Experiment Station, I had agreed to pursue this objective for the North Central Regional Committee.

The first idea was that disaggregation would be on the demand side (animal class subdivision) and on the supply side (both feed grains and livestock) and that the procedure would follow an inter-regional programing model. After studying the problem, I was convinced (and the committee agreed) that (1) disaggregation on the demand side was most significant, (2) supply function determination would be too arbitrary, whether on a predictive-descriptive or efficiency basis of development, (3) long-run and interannual analyses were more significant than short-period considerations and therefore one could assume that supply would follow (or be controlled to be consistent with) demand, with the locational aspects of supply adequately appraised by simpler procedures than a cumbersome programing model, (4) inadequate regional data and detailed transportation and conversion costs would lead to concern over the meaningfulness of programed results, (5) modification on the programing model to answer certain dynamic and inter-temporal problems might not prove feasible, (6) information relevant to agricultural policy should be stressed, and (7) I was a firm supporter of the superior methodology of the programing model for normative efficiency analyses, but questioned whether merely showing the capability for handling the computing problem was justifiable when the data input would have been quite arbitrary in some dimensions.

With this background, the reader can appraise whether the procedures and issues developed in this research do provide some answers to the basic problems inherent in the complex livestock-feed economy. The material is presented in a condensed form throughout and reading it might require concentration. It is hoped that the reader will feel a measure of charitable sympathy for the problem of simplifying the discussion of any complicated structure.

Sources of data are not stated explicitly in the report. They can be found in the various U.S.D.A. situation reports on livestock, poultry, dairy, and feed.

The term “feed concentrates” includes the major feed grains, other grains fed, protein supplement feeds, and by-product feeds. Certain sections of the report will involve relationships for feed grains only, and appropriate assumptions relating to complementarity between
grains and supplements in balanced rations will be made at those points. References to feed conversion rates may be found in "Consumption of Feed by Livestock, 1909-56," Production Research Report No. 21, by R. D. Jennings, U.S.D.A., and several of the recent "Agricultural Outlook Charts." Most of these rates have been adjusted to account for losses and breeding unit requirements.

**SUMMARY AND CONCLUSIONS**

This section contains some of the more generalized highlights of the study, the methodology used, and an interpretative outline. No attempt is made to repeat many of the specific details here. These can be understood only in their context in the report.

Several major problems beset the livestock-feed economy of the U. S., namely, (1) "excessive" total feed concentrate (feed grains, other grains fed, protein supplements and by-product feeds) production relative to demand levels at "reasonable" prices for livestock and feed grains, (2) disequilibrium levels and variations in livestock and poultry production rates between classes and over time which reflect consistent disequilibrium rates in feed concentrate utilization, (3) adjustments to technological changes (such as feed conversion rates) and to different growth rates for the terminal animal product demands, and (4) factors that influence interregional competition, trade, and specialization.

This study developed some analytic procedures for appraising these problems, with quantitative estimates of the basic and derived demand structures as well as specific measures of the amount of disequilibrium in the actual activities of the livestock-feed economy during the past decade. Demand projections were made for animal products and their feed concentrate equivalent for the 1960-70 period. A section of the report appraised the dynamic race between the growth rate in the demand for feed concentrates and the productivity increases in feed grain production. Finally, the effects of transportation rates and conversion factors were formalized for use in considering problems of interregional competition and regional specialization.

The demand side of the market was stressed. This was intentional. In complex markets having very inelastic demands and quite elastic supply potential, the supply side of the market must follow the relatively rigid structure of final demands of chaotic price variation results. Furthermore, for any given level of feed concentrate supply, a short-run equilibrium utilization problem arises that is almost entirely dependent on the demand structure of the final animal products and the predetermined size of the beef herd.

After a brief introduction, the demand functions for animal products at the retail level were quantified on a per capita basis for the aggregate U. S. market. The separate categories that were considered were (1) beef and veal combined, (2) pork (excluding lard), (3) broilers (including all chicken meat), (4) turkey, (5) eggs, (6) milk for fluid
consumption, and (7) milk for manufactured dairy products. The first three categories were treated as interdependent substitutes in demand and were the only products in the seven groups that were considered to have some price elasticity over the relevant range of potential price variation. These demand function formulations were of the static type and employed disposable income as the principal demand shifting force on a per capita basis.

The next step, in the process of eventually quantifying the derived demand for feed concentrates, was to develop the demand functions for the animal product forms at the farm level. Two transformations on the retail demand functions were required. First, the physical retail quantities were converted into their farm level equivalents by means of appropriate conversion factors. Secondly, the retail prices (for those products having demand functions that were price dependent) were transformed into consistent farm level prices for farm level forms. Market system price functions were estimated for this purpose and employed the wage rate of food distribution employees as a shift variable to account for changing processing and distribution cost levels over the time series period. This reduced the likelihood of securing excessively biased estimates of parameters in the price functions that should tend to reflect conversion factors and other processing costs not correlated with wage rates.

One further stage of transformations was necessary in securing the farm level derived demand functions (and the equilibrium aggregate demand function(s)) for feed concentrates. The physical animal product forms at the farm level had to be converted into feed concentrate equivalent. This was accomplished by employing average feed to animal product conversion rates and making allowances for culled dairy and beef cattle, culled hens, and beef production based on forage consumption. The prices for the animal forms also had to be transformed into consistent feed concentrate net values. Because the prices received by farmers for feed concentrates (corn, for instance) did not accurately reflect the net value earned at each point in time for a given feed conversion activity, regression estimating procedures for determining the specific feed value productivity functions could not be employed. Synthetic feed value functions were developed, algebraically, to connect derived feed values and animal product prices. These were based on feed conversion factors and average feed-livestock price ratios. Only those animal classes having price dependent demand functions (beef cattle, hogs, and broilers) required these value transformations. Finally, by imposing the equilibrium requirement that feed concentrates have equal value in alternative uses, the separate demands were aggregated into a single function. These functions were on a per capita basis. Total demand functions were secured by multiplying by the population size and making a direct allowance for "other uses" for feed concentrates.
Equilibrium, short-run solutions for feed concentrate utilization patterns and values were computed for the years 1950 and 1959. These solutions were contrasted with actual results for the industry as an example of a possible efficiency evaluation usage of the derived demand functions. Subsequently, a continuous series of these short-run solutions for the entire 1949-59 period provided a comparative basis for appraising the performance of the industry over these years.

In general, the feed utilization patterns indicated rather poor adjustment to the cattle cycle and the price support programs. Net overutilization amounted to about 9.5 million tons, with underutilization of 16.0 million tons for 1949-52 and 3.5 million tons for 1958-59 and with overutilization of about 29.0 million tons during 1953-57. Utilization rates among the livestock classes deviated rather significantly from the computed equilibrium rates.

The next section of the report considered dynamic or temporal features of the demand structure with two principal objectives. First, an appropriately useful analytic procedure had to be developed in a general form to provide a research tool that would permit quantitative estimates to be made for the direct and indirect effects on the demand structure of changes in certain fundamental factors (population, income, marketing costs, and conversion rates). Except for population, which had an approximate geometric trend, linear trends were used for the other factors. Upon substituting these trend functions into the appropriate positions in the primary demand functions, it was possible to state the demand structure as a function of time, price, and the underlying demand and trend parameters. The second objective was to project the demand structure for the 1960-70 decade. This was accomplished by estimating the population, income, and marketing cost trend functions from 1949-59 data and making a few reasonable assumptions about future trends in conversion rates.

The race between the demand growth rate and productivity trends in feed grain production was analyzed next. Several policy issues associated with this problem were appraised, including stocks for stabilization purposes, estimated recent surplus stocks, and land requirements. Stabilization of livestock population trends was noted as a consistent factor for stability in the industry. The more reasonable and somewhat conservative projection indicated that demand levels by 1970 will not press on supply capability and land needs will still be less than what would be necessary to meet current demand.

The entire analysis up to this point employed no direct accounting for the important spatial features of the supply and demand sides of the livestock-feed market structure. Major public and private policy decisions cannot ignore the geographic aspects of this complex industry. Consequently, the last section of this report develops some analytic methods for the solution of specific and general problems in the spatial setting. These developments indicate the logical ways of employing
the significant factors of transportation costs and conversion factors in answering questions related to interregional shipments and the location of feeding and processing facilities. The economic bases for transportation rate policy are significantly dependent on the basic location of excess consumer demands and excess beef and feed grain supply areas in conjunction with transportation costs and conversion rates.

Although numerous conclusions could be stated that would reflect the direct or implied importance of the sequential results that were developed in this study, only a few of the more important ones will be listed in this summary. It is possible that the methodological developments in the report are of more importance than some of the more practical conclusions that are inherent in the estimates. Some of the significant results are as follows:

1. Retail demand functions for animal products are inelastic, both with respect to price and income.

2. The aggregate demand function for feed concentrates at the farm level is very inelastic with respect to price, being less elastic than $-0.10$. Furthermore, the income elasticity also is very low, with a value of only $0.11$.

3. The historical appraisal for the 1949-59 period, based on a series of comparative static analyses, indicated (a) the feed concentrate utilization pattern did not adjust efficiently to the cattle cycle, and disequilibrium usage between livestock classes was prevalent, (b) farmers did not take full advantage of the feed grain price support alternative, and (c) imputed net values from using feed concentrates in animal product production have deviated quite significantly from the reported prices received by farmers from cash sales.

4. The dynamic analysis of the demand structure for feed concentrates for the 1949-59 period and projections to 1970 indicated (a) rising marketing costs about neutralized the rising income effect on a per capita basis, (b) utilization for beef, broiler, and turkey production have demands that rise more rapidly than population, (c) demand for feed utilization in milk production was depressed below the population rate from 1949 to 1959 mainly because of the substitution of margarine for butter, (d) demand for feed concentrates to be used in pork and egg production has been increasing and will undoubtedly continue to increase at rates much below the population growth rate, and (e) total feed concentrate demand increased at a decreasing rate and more slowly than population from 1949 to 1959 with projections to 1970 indicating a growth rate most likely below the population rate.

5. Yield per planted acre for feed grains has been increasing at a rate of about 32.5 pounds per acre per year on the average. This is probably conservative for future projections. Estimated land needed to meet demand for feed grains would have dropped from about 150 million acres in 1948 to slightly more than 140 million acres
by 1959. An optimistic projection for the 1969 crop year indicated an acreage of 144 million would be needed, while a conservative projection would suggest that the needed acreage could drop to 137 million acres or less. Improvements in the yield rates and the animal conversion rates could drop the needed acreage even lower. Normal demand growth will not put pressure on land requirements by 1970 for the feed concentrate—livestock industry.

6. Analytic models were developed to study problems of interregional competition and regional specialization. An increasing share of the future growth of demand for animal products in the Pacific Coast Region (especially beef) should accrue to Midwestern producers. Furthermore, the demand for inshipments of feed grains from the Midwest to deficit feed grain production areas is based primarily on animal product forms that are price inelastic. Increasing transportation rates on grains should not depress these demands or prices for feed in the surplus area. By the logical use of conversion factors and transportation rates one can indicate a zonal pattern for animal product activities and processing facilities. In general, major livestock production areas are consistent with these analyses, but persistent disequilibrium over time between the levels of livestock activities encourages more diversification than would be implied from basic determinants of locational comparative advantage.
The U.S. Feed Concentrate—Livestock Economy’s Demand Structure, 1949-59
(With Projections for 1960-70)

James B. Hassler

INTRODUCTION

This report will be concise. Little space will be devoted to lengthy arguments about estimation techniques or alternative formulations. Important assumptions will be stated, but peripheral arguments about the nature of production functions, micro-unit diversity, decision-making processes, and aggregation implications will be omitted. Consistent presentation of the basic structural analysis and inferences drawn from these results will be stressed.

The major objectives of this study are (1) to quantify the demand functions for the major animal products of agriculture at the retail level, (2) to derive the demand functions for the unprocessed forms at the farm level, (3) to derive the equilibrium demand functions for feed concentrates at the farm level, (4) to estimate the separate annual impact rates of trends in per capita income, marketing costs, conversion rates, and population on the derived demand for feed concentrates, (5) to contrast the historical results of the industry with several conditional equilibrium solutions, (6) to draw inferences from the demand analyses relevant to national agricultural policy, and (7) to draw inferences relevant to interregional competition and transportation policy.
DEMAND STRUCTURE – STATIC APPRAISAL
Definitions of Variables and Basic Data

1. Definitions of variables (U. S. averages unless otherwise specified)

\( X_1 = \) Per capita beef and veal consumption per year (lbs.)
\( X_2 = \) Per capita pork (excluding lard) consumption per year (lbs.)
\( X_3 = \) Per capita chicken consumption per year (lbs.)
\( X_4 = \) Per capita turkey consumption per year (lbs.)
\( X_5 = \) Per capita egg consumption per year (doz.)
\( X_6 = \) Per capita fluid milk and cream consumption per year (lbs. of milk equivalent)
\( X_7 = \) Per capita manufactured dairy products consumption per year (lbs. of milk equivalent)
\( X_8 = \) Per capita margarine consumption per year (lbs.)
\( X_9 = \) Per capita disposable income per year (dollars)
\( X_{10} = \) Wage rate for food distribution employees (dollars per hr.)

\( P_1 = \) Retail beef price (cents per lb.)
\( P_2 = \) Retail pork price (cents per lb.)
\( P_3 = \) Retail broiler price (cents per lb.)
\( P_5 = \) Retail egg price (cents per doz.)

\( P_1' = \) Omaha “farm” price for choice beef cattle (cents per lb.)
\( P_2' = \) Omaha “farm” price for choice hogs (cents per lb.)
\( P_3' = \) “Farm” price for broilers (cents per lb.)
\( P_4' = \) “Farm” price for turkeys (cents per lb.)
\( P_5' = \) “Farm” price for eggs (cents per doz.)

\( P_6 = \) “Farm” blend price for Grade A milk (cents per lb.)
\( P_7' = \) “Farm” price for manufacturing milk (cents per lb.)

\( N = \) U. S. population including armed forces overseas (millions)
\( P_b = \) “Farm” price for broiler growing mash (cents per lb.)
\( P_E = \) “Farm” price for laying mash (cents per lb.)
\( P_D = \) “Farm” price for dairy ration (cents per lb.)

\( P = \) “Farm” price for concentrates based on corn (cents per lb.)
\( P* = \) Value productivity of concentrates in \( i^{th} \) use (cents per lb.)

\( Y_1 = N X_1 \)

\( Q_0 = \) Annual usage of feed concentrates other than by beef cattle, dairy cattle, broilers, hens, turkeys, and hogs (millions of lbs.)
\( Q_i = \) Concentrates fed in \( i^{th} \) use per year (millions of lbs.)

\( Q = Q_0 + \sum_{i=1}^{7} Q_i \)

\( t = \) Time in years (1949 = 0)

2. Basic data (1949-59)

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ANIMAL PRODUCT DEMAND AT RETAIL LEVEL
(per capita basis)

Beef and Veal, Pork, Chicken

The treatment of the price structure for beef and pork assumes that the price levels are flexible and dependent on the predetermined volumes that must be cleared in the market. Beef, pork, and chicken are assumed to be partial substitutes in demand. The annual average price of broilers is assumed to be primarily predetermined by supply costs, and consequently the volume of broilers supplied and consumed is a function of the price aspects of the beef and pork volumes in conjunction with the broiler price level. Long and short production time requirements underlie the difference in the treatment of beef and pork compared with broilers.

Per capita disposable income is employed as the principal demand shifting force. Current prices and values are used to simplify the projective use of the model. Logically, except at extremes, the impact of inflation or deflation is manifested primarily in non-food economic areas. Furthermore, many of the internal relative price relationships for the livestock-feed sector would be invariant under inflation-deflation.

The basic analysis is on an annual time period and a national geographic coverage. Under stable patterns of surplus and deficit cells this procedure is acceptable. Interregional relationships can be related

2 When the product beef is referred to in a demand context, it will be understood to include veal.

a Broiler is to be understood as inclusive of all chicken meat when discussed in a demand context. The following estimated price equation supports the supply cost argument, when the trend in conversion rates for feed into chickens is taken into account.

\[ P' = 1.751641 + 5.520735 P_B - 0.241191t P_B \]

\( R^2 = .928 \)

This equation can be converted to

\[ P'_a = 1.751641 + (5.520735 - 0.241191t)P_B \]

to emphasize the linear time trend in the conversion coefficient. The size of the estimated conversion coefficient (5.5 in 1949 to 3.1 in 1959) from price data suggests that broiler prices were related to marginal supply cost for farm-raised chickens in the early years (specialized broiler operations—an innovating production function—were realizing short-run excess profits) and for specialized broiler operations now. The size of the constant term, 1.75, is too low to represent average non-feed costs of production. Scale economies may have resulted in many other cost factors being correlated with feed prices (even though unit input prices were rising) so that the conversion coefficient is inflated to carry these correlated items. The mixture form of the industry would have a similar impact on the estimated coefficients. The figures in parentheses in the above equation and throughout the text at other points are the estimated standard deviations for the respective regression coefficients.
to the average results. Some spot markets are employed instead of the national averages. These should be self-evident from the previous definitions.

Only linear structures are estimated. For many of the conversion and market system functions in a competitive structure, the linear arithmetic form is logical. Other parts of the structure (demand at retail) are treated linearly, although other formulations of an arbitrary form would be acceptable on a priori grounds. Using linear functions and transformations greatly simplifies the derivation of sub-level demand functions and the logical interpretation of the procedures and results.

Separate price functions for beef and pork were estimated. They are:

$$P_1 = 113.064522 - 1.248734 X_1 - .366001 X_2 + .050617 X_9$$

$$R^2 = .989$$

$$P_2 = 169.055441 - .434568 X_1 - 1.333533 X_2 + .008491 X_9$$

$$R^2 = .811$$

The demand for broilers was considered to depend on the supplies of beef and pork, the price of broilers, and per capita disposable income. Consequently, the following function was estimated.

$$X_3 = 43.953737 - .161762 X_1 - .135032 X_2 - .299501 P_3 + .011051 X_9$$

$$R^2 = .961$$

The two price functions ($P_1$ and $P_2$) were simultaneously transformed into

$$X_1 = 59.024255 - .885377 P_1 + .243000 P_2 + .042752 X_9$$

$$X_2 = 107.537981 + .288524 P_1 - .829076 P_2 - .007565 X_9$$

for later usage and to reflect the quantity dependent form for a demand function. Upon substitution of these results into the broiler demand function it becomes

$$X_3 = 19.884766 + .104260 P_1 + .072644 P_2 - .299501 P_3 + .005157 X_9.$$
The consistent "own price" elasticities of demand are -.74 (beef), -.76 (pork), and -.51 (chicken). The income elasticities of demand are .93 (beef), -.23 (pork), and .36 (chicken). Cross elasticities of demand are: (1) for beef, .16 with respect to pork price; (2) for pork, .34 with respect to beef price, and (3) for chicken, .28 with respect to beef price and .16 with respect to pork price.

Turkey

Terminal demand for turkey is primarily for holiday home use and use by restaurants or institutions. Since the supply cost of turkey is higher than for chicken, the potential substitution of turkey for chicken is normally blocked by price. The size of a turkey also reduces its competitive flexibility for regular home use. Based on these reasons and historical evidence, the demand for turkey meat was taken as perfectly inelastic with respect to price. Most of the recent changes in per capita utilization are associated with rising income which permits more families to use turkey on holidays and take more meals at restaurants. Consequently, the demand for turkey was estimated as

\[ X_4 = -1.588495 + .004064 X_9 \text{ with } r = .964. \]

If \( X_9 \) has a value of 1,950, then \( X_4 = 6.34 \) and the consistent income elasticity at that point is about 1.25.

Eggs

Several formulations (including simultaneous demand-supply systems) of demand functions for eggs that considered the potential of interdependence between price and volume were quantified and discarded. There appeared to be no statistically significant evidence that per capita demand for eggs was influenced by experienced variation in price levels since 1949. The following simple function of per capita disposable income is used:

\[ X_5 = 40.128783 - .005591 X_9 \text{ with } r = -.873. \]

Although no attempt was made to subdivide this total per capita demand relationship into the several possible parts, it might be appropriate to discuss the implications of the negative income effect. With no direct evidence to support the argument it may be in error, but, it could be conjectured that most of this negative income effect is a result of the use of eggs for bakery products and in ice cream. Use of shell

---

\( ^4 \) Turkey prices seem to ride the crest of broiler prices, reflecting the superior competitive strength of the broiler operations. The following relationship supports this argument.

\[ P' = 8.247845 + .919242 P'_e \text{ with } r = .931. \]
eggs for home or restaurant meals may not have this negative income effect. In fact it could have a slight positive relationship to income. The calculated income elasticity for the above relationship is \(-0.37\), when \(X_9 = 1,950\).

**Milk**

Many milk products are consumed at retail. No attempt was made to estimate the quantitative aspects of this complex structure. The major processing subdivisions for milk are (1) for fluid consumption and (2) for manufactured products. It is at this level that the demand for milk products was considered. Historical evidence and several demand studies fail to support the contention that price levels or income levels have had any significant effect on consumption rates in recent years. The consumption (not the price) of margarine has had a significant effect on butter demand and the derived demand for milk.

The demand for milk for fluid purposes was estimated as \(X_6 = 350\) pounds per capita per year.

The demand for milk for manufactured dairy products was estimated as \(X_7 = 460.468773 - 13.346765 \times X_8\), with \(r = -0.909\). Notice that the consumption of a pound of margarine displaces slightly over 13 pounds of milk or about two-thirds of the milk equivalent of a pound of butter.

**UNPROCESSED FORM DEMAND AT FARM LEVEL**

*(per capita basis)*

**Beef cattle, hogs, broilers**

The retail demand functions for beef, pork, and broilers must be transformed to the farm level. This requires that \(P_1, P_2,\) and \(P_3\) be converted to their functional equivalents in terms of \(P_1', P_2',\) and \(P_3'\), reflecting the manner in which the market relates values between retail and farm levels under the influence of conversion factors and processing and distribution costs. A second requirement for this transformation is the physical conversion of retail products into their farm level equivalents.

Market system price functions were estimated and converted as follows:

**Beef**

Estimated as: \(P_1' = 8.925104 + 0.438886 \times P_1 - 7.092459 \times X_{10}\)

\[R^2 = 0.976\] Converted to: \(P_1 = 2.278496 \times P_1' + 16.160140 \times X_{10} - 20.335814\)
Pork
Estimated as: $P_2' = -4.989366 + 0.591525 P_2 - 6.261187 X_{10}$

$R^2 = .967$

Converted to: $P_2 = 1.690546 P_2' + 10.584822 X_{10} + 8.434751$

Broilers
Estimated as: $P_3' = -13.467702 + 0.697913 P_3$

$r = .994$

Converted to: $P_3 = 1.432843 P_3' + 19.297107$

The variable $X_{10}$ in the previous functions was employed as an “index” variable to reflect the price effects of labor and correlated inputs (pricewise) on processing and distribution costs. The coefficients on $X_{10}$ should not be interpreted as unit labor requirements, since $X_{10}$ is a “carrier” variable for many other factors.

The coefficients on $P_1$, $P_2$, and $P_3$ should reflect conversion factors in a competitive system. However, $P_1$ and $P_2$ are valuations on high value components of the original animals and as such would not necessarily reflect yield rates. Similarly, the constant terms 8.93 and $-4.99$ do not just reflect other average processing costs not correlated with $X_{10}$, but also include a portion of average by-product values. The relationship between $P_3'$ and $P_3$ reflects more accurately the yield factor, $0.70$, and the costs of processing and distribution, $-13.47$, consistent with a competitive structure. The variable $X_{10}$ was not significant in the latter case—perhaps indicative of the impact of special retail pricing and improvements in processing and distribution on neutralizing factor price increases over the period 1949-59. This may not continue into the future.

Physical transformation functions used to convert $X_1$, $X_2$, and $X_3$ (pounds of retail beef, pork, and broilers) into $X_1'$, $X_2'$, and $X_3'$ (pounds of cattle, hogs, and live broilers) are:

$X_1' = X_1 / 0.55$, $X_2' = X_2 / 0.56$ and $X_3' = X_3 / 0.70$

Upon substitution of the marketing system price transformations and the physical conversion relationships into the retail demand functions, we secure the farm level derived demand functions for slaughter cattle, slaughter hogs, and live broilers. These are on a per capita basis and are as follows:

$X_1' = 143.779565 - 3.667869 P_1' + 0.746915 P_2' - 21.337644 X_{10}$
$\quad + 0.077731 X_9$

$X_2' = 169.067073 + 1.194802 P_1' - 2.502841 P_2' - 7.347036 X_{10}$
$\quad - 0.013509 X_9$

$X_3' = 17.996836 + 0.339366 P_1' + 0.175440 P_2' - 0.613054 P_3' + 3.576829 X_{10}$
$\quad + 0.007367 X_9$
Turkey

Since turkey demand at the retail level was considered perfectly inelastic (over a reasonable range) with respect to price, no price variable appeared in the demand function. Consequently, the conversion to the farm level demand for live turkey, $X_4'$, only requires the transformation due to physical conversion. This relationship is $X_4' = X_4/.77$. Therefore, the farm level demand function on a per capita basis is $X_4' = -2.062981 + .005278 X_9$.

Eggs

Retail demand for eggs was also considered to be independent of price level (over a reasonable range dictated by relative supply costs). No loss factor is included for breakage and spoilage between the farm and retail level. All other animal products were considered similarly. Loss rates are small, but could be included if desired. Since all egg usage was on a shell egg equivalent basis of average size, the dozen measurement requires no physical conversion. Consequently, farm level demand is identical with retail level demand, namely $X_5' = X_5 = 40.128793 - .005591 X_9$.

It is appropriate at this point to say something about the price structure for these products (turkey, eggs, and milk) whose consumer demand functions are considered independent of price. Basically, the price structure of such products having potential storeability is determined by competitive supply costs and the interaction between storage stocks and current production. Supply costs set the initial price level and the reservation demand maintains price stability consistent with storage costs and the entry-exit flexibility in production. A combination of value productivity functions for feed conversion and market price functions between levels in the market would provide us with these price structure estimates. Since this study is primarily concerned with the derived demand structure for feed concentrates, only the price elastic sectors (beef, pork, and broilers) of demand require price transformations. Only the quantitative aspects of turkey, egg, and milk demands need to be included in the derivation of the feed concentrate demand function and its component parts.

Milk

Assuming no loss between levels in marketing milk, the milk equivalent demand at the farm level is the same as the retail level demand. Consequently, $X_6' = X_6 = 350$ pounds per capita and $X_7' = X_7 = 460.468773 - 13.346765 X_8$. 

17
DERIVED DEMAND FOR FEED CONCENTRATES
AT FARM LEVEL

Long-run situation

The previous section developed the derived demand structure for the unprocessed animal product forms at the farm level. Transforming these demands into derived demands for feed concentrates is the subject of this section. The following considerations are involved in these transformations: (1) Part of the beef supply is produced independently of feed concentrate use. Forage is used for the early development of most beef animals and culling of dairy and beef herds accounts for another component of beef supply. Only the tonnage added in finishing operations can be represented as a demand for feed concentrates.\(^5\) We shall designate that part of the beef supply (in retail product weight) that is independent of feed concentrate conversion as the beef base, B. At a later point we shall assume certain magnitudes for B—primarily based on technological complementarity and demand rigidities. (2) Feed concentrate use by dairy cattle and by hens will be allocated completely to the output of milk and eggs. Cull dairy cattle and hens will be allocated to the beef base, B, and to the chicken base, C, on the predetermined supply side of the market. The demand for feed concentrate to be used in the production of "farm raised chickens" is considered to be price inelastic in the short-run and long-run. Essentially, this demand is predetermined and fixed in any given year and is reduced between years to slowly reflect the superior competitive strength of commercial broiler operations. The long-run path is assumed to lead to a terminal level for farm raised chickens (excluding hens that are allocated to the chicken base) of 140 million retail weight pounds per year in the near future. Eventually, this could drop to 50 million pounds or less. (3) Physical conversion from unprocessed farm level animal product forms to feed concentrate equivalent is based on the following factors:

(a) 7.0 pounds of feed concentrate for 1.0 pound of added gain on beef cattle.
(b) 5.0 pounds of feed concentrate for 1.0 pound of live hog.
(c) 3.5 pounds of feed concentrate for 1.0 pound of live broiler.
(d) 5.5 pounds of feed concentrate for 1.0 pound of farm raised chicken.
(e) 5.5 pounds of feed concentrate for 1.0 pound of live turkey.

\(^5\) Roughage is part of the feedlot ration. It is treated as part of the "other production costs" in the value productivity function for beef finishing operations. Assuming that complementarity between roughage and feed concentrate is approximately in fixed proportions, the physical conversion is made proportional to feed concentrate usage.
7.0 pounds of feed concentrate for 1.0 dozen eggs.

.33 pounds of feed concentrate for 1.0 pound of milk.

These conversion factors are considered relevant for the present and near future. Later sections of this report dealing with the historical appraisal and the impact of changing conversion rates will use conversion rates related to these problems. In all cases the rates include relevant feed requirements for the breeding units that generate the terminal animals. The rates also account for associated supplements converted to a corn equivalent basis. Death losses are not accounted for directly, but it is believed that the conversion rates listed are large enough to cover this loss factor.

The prices $P_1'$, $P_2'$, and $P_3'$ must be transformed into feed concentrate values $P_1^*$, $P_2^*$, and $P_3^*$. This is accomplished by substitution of the value productivity relationships connecting $P_1'$ and $P_1^*$, $P_2'$ and $P_2^*$, and $P_3'$ and $P_3^*$ into the farm level demand functions for unprocessed animal forms developed in the previous section. These value productivity functions and their bases are as follows:

**Beef Finishing Operation**

$$P_1' = 6.09P_1^* + 11.73$$

is based on 7.0 pounds of concentrate per pound of gain, 1.0 pound of beef (liveweight) equal to value of about 11.0 pounds of corn (10.974 pounds for computing purposes) when corn averages 2.40 cents per pound (a procedure to estimate the more rigid costs of production exclusive of grain), feeder cattle price at 90 percent of slaughter price, and 600 pound feeders finished at 1,000 pounds.

**Hog Producing Operation**

$$P_2' = 5.00P_2^* + 7.20$$

is based on 5.0 pounds of concentrate per pound of liveweight production and 1.0 pound liveweight equal to value of 8.0 pounds of corn when corn averages 2.40 cents per pound.

**Broiler Producing Operation**

$$P_3' = 3.50P_3^* + 5.09$$

(where $P_3^*$ is the value per pound for broiler growing mash) is based on 3.5 pounds of mash per pound of liveweight production and 1.0 pound liveweight equal to value of 4.5 pounds of mash when mash has an average value of 5.09 cents per pounds. This relationship is converted to a corn basis by the relationship

$$P_3 = 3.494 + .666 P \quad (0.093)$$

with $r = .923$.

The final productivity function is

$$P_3' = 2.33 P_3^* + 17.32.$$

The logical equilibrium specification that the value productivities of feed concentrates in alternative uses should be equal to each other and to the market price of corn equivalent is imposed so that aggrega-
tion of the different demand functions for feed concentrates can be accomplished. Therefore \( P_1^* = P_2^* = P_3^* = P \) is imposed for equilibrium demand in the long-run. (6) Total demand for feed concentrates is the sum of two parts, namely, (a) the total for the categories considered thus far in this report, secured by multiplying the derived per capita demands by the size of the population, and (b) the total for all other uses (feed for sheep, horses, mules, and other animals, seed, human food, industrial use, and net exports). The latter component is considered to be approximately fixed in total and inelastic with respect to price. We shall assume this magnitude, \( Q_{0r} \), to be equal to 66,000 million pounds per year—approximately the average level in recent years. It is a sizeable component, but the gain from this simplifying assumption more than offsets the minor loss in realism.

Applying these considerations to the demand results of the last section gives the following partial and total equilibrium demand functions for feed concentrates:

**Beef Sector**

\[
Q_{1t} = N_t (742.982750 - 130.219229 P_t - 149.363508 X_{10t} + .544117 X_{9t}) - 12.727273 B_t
\]

\[
= N_t (222.879826 - 39.065768 P_t - 44.809052 X_{10t} + .163235 X_{9t})
\]

when \( B_t = .70 Y_{1_t} \), that is, the beef base supply equals 70 percent of the total beef demand at all levels. Therefore, only 30 percent of beef demand will represent demand for feed concentrates.

**Pork Sector**

\[
Q_{2t} = N_t (825.308225 - 26.189305 P_t - 36.735180 X_{10t} - .067545 X_{9t})
\]

**Broiler and Farm Raised Chicken Sectors**

\[
Q_{3t} = N_t (44.179352 + 5.304331 P_t + 12.518902 X_{10t} + .025785 X_{9t}) + 400 - 5.000000 C_t
\]

\[
= N_t (8.771712 + 5.304331 P_t + 12.518902 X_{10t} + .025785 X_{9t} + .004935 X_{9,t-1}) + 400
\]

when \( C_t = .025210 Q_{5,t-1} \), which assumes that \( C_t \) comes from the hens required to produce the eggs of the previous year and that each hen yields 3.0 pounds of retail meat and produces 17 dozen eggs per year requiring 7.0 pounds of feed concentrate per dozen eggs. The value 400 is the extra feed required for the assumed fixed 140 million pounds of retail chicken produced by farm practices instead of commercial broiler practices. This is equivalent to \((5.5 - 3.5) (140 / .7)\), representing the 2.0 pounds of extra feed times the 200 million pounds of liveweight equivalent.

The positive coefficients on \( P_t \) and \( X_{10t} \) should be explained.

Increasing feed prices are associated more with greater increases in the consistent price levels for beef and pork than for broilers and the consumer substitution effect produces a small net positive gain for
broilers over the negative effect of a higher price level. Similarly, the earlier relationships between beef, pork, and broiler retail and farm prices indicated that “marketing costs” had negative effects for beef and pork, but no effect for broilers. A combination of retail special pricing and improvements in processing and distribution appear to have offset rising factor prices in broiler marketing. Therefore, the interproduct substitution effect gives a positive gain to broilers as marketing costs rise. Undoubtedly, this will not continue to be so strong in the future and may eventually become negative. The short-run concentrate demand function for broiler operations does have a negative feed price coefficient, if feed use in beef and/or pork operations is considered predetermined or biological inflexibilities fail to permit full adjustments.

Turkey Sector
\[ Q_{st} = N_t (-11.346396 + .029029 X_{9t}) \]

Egg Sector
\[ Q_{st} = N_t (280.901551 - .039137 X_{9t}) \]

Fluid Milk Sector
\[ Q_{ot} = N_t (115.500000) \]

Manufacturing Milk Sector
\[ Q_{7t} = N_t (151.954695 - 4.404432 X_{8t}) \]

Other Use Sector
\[ Q_{ot} = 66,000 \]

Total Demand
\[ Q_t = 66,400 + N_t (1593.969618 - 59.950742 P_t - 69.025330 X_{10t} + .111367 X_{9t} + .004935 X_{9,t-1} - 4.404432 X_{8t}) \]

These results represent the estimated equilibrium demand structure for feed concentrates in the United States. Because of the specific conversion factors employed, they are most relevant for current conditions. Without creating any conflict with historical comparative analyses to be considered later, it should be instructive to evaluate certain aspects of this structure for conditions existing in 1959. It should be emphasized that these derived demand functions are long-run in nature, that is, they assume full long-run average cost coverage for feed conversion activities and marketing processes and consistent livestock activities in terms of equal value productivity for feed usage. Short period biological inflexibilities are ruled out—livestock numbers are fully adjustable to consistent interdependent levels. Assumptions about the beef base, the chicken base, the “farm raised chicken” operation and the “other uses” category are considered valid.

The variables \( X_{8t}, X_{9t}, \) and \( X_{10t} \) are considered as being exogenously determined for the livestock-feed economy. We shall use \( X_8 = 9.2, \)
X_9 = 1,893, and X_{10} = 2.06 for 1959, and assign a value of X_9 = 1,835 for 1958 instead of the realized value of 1,818. The latter decision is consistent with an average annual increment of $58 per capita disposable income for the 1949-59 period. We shall evaluate the demand structure at a price level of P = 2.00 cents per pound of corn equivalent—approximately the 1959 price support level. The value for N is 177.1 million persons. Table 1 summarizes these results.

Table 1. U. S. Long-Run Demand Characteristics for Feed Concentrates, 1959

<table>
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<tr>
<th>Use Sector</th>
<th>Quantity (Million Pounds)</th>
<th>Price Elasticity</th>
<th>Income Elasticity</th>
<th>&quot;Marketing Cost&quot; Elasticity</th>
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</tr>
<tr>
<td>Pork</td>
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<td>-.11</td>
<td>-.22</td>
<td>-.13</td>
</tr>
<tr>
<td>Broiler</td>
<td>17,548</td>
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<td>.50</td>
<td>.26</td>
</tr>
<tr>
<td>Farm raised chicken</td>
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<td>0</td>
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<tr>
<td>Turkey</td>
<td>7,723</td>
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</table>

* Assumes X_9 = $1,893 (1959), $1,835 (1958), X_{10} = $2.06, X_s = 9.2 pounds, N = 177.1 million persons, and P = 2.00 cents per pound.

Although the information in Table 1 requires little elaboration, certain aspects should be understood. At a price level of 2.00 cents per pound of corn equivalent in 1959, the equilibrium demand (utilization) consistent with this price level would be about 167.0 million tons in total and allocated as indicated in the quantity column. Notice the extremely small total demand elasticities even though a few of the income elasticities for single uses are relatively larger. The large number of zero elastic components reduced the elasticity measures for the total demand. Actual utilization in 1959 was approximately 179 million tons—partially explained by a beef base much smaller than the assumed 70 percent of total supply, by other short-run disequilibrium allocations, and by failure to cover all costs of conversion. This issue will be considered in detail in a later section devoted to historical appraisal.

The Short-Run Conditional Situation

The previous section considered the long-run static situation—the structure was assumed to have the capacity for complete equilibrium adjustments. Ignoring the reservation demand for carryover feed and livestock between crop years (a significant factor for free market analysis—but less significant under heavy surplus carryover or planned public carryover), one might be interested in the intraannual adjustments and decision processes for a single period.

Several conditionally fixed situations will be postulated for single period analyses of short-run demand structures for feed concentrates.
Historical evidence indicates that the beef cattle industry has produced at rates that appear as rough cycles. In a general sense, "excessive" volumes of beef cattle are equivalent to a reduced demand for feed concentrates, representing the substitution of forage for concentrates. "Short" volumes of beef cattle are equivalent to an increase in demand for feed concentrates. Consequently, the size of the beef base, B, is a significant factor underlying feed concentrate demand, and because of the long period production activity for beef cattle it is not unreasonable to assume the beef base to be a short-run fixed condition.

Two components of chicken meat supply will be considered predetermined. The volume of meat coming from egg producing flocks will be taken as determined by the aggregate average size of the flock in the previous year. A yield of three pounds per hen producing flocks will be assumed. Since the size of the national flock has been relatively stable, this assumption does not distort the culling volume even though the average economic life span of hens is longer than one year—perhaps 15 to 18 months from hatch. The laying life span would approximate one year. In the short-run period, it will be assumed that the volume of farm raised chickens is independent of current economic criteria, such as chicken and feed grain prices, and consequently predetermined. In an ex post sense the actual volume for the period could be employed. Ex ante analyses could only specify that this component was fixed without stating the actual volume. Predictive models would require a segment that "explained" or predicted this magnitude in advance.

During open market periods, one might consider the supply (and use) of feed concentrates fixed (ignoring the carryover problem by assuming only a minimal, fixed, "pipe-line" volume or that actual carryover would not have been changed by a shift for the use pattern) by the predetermined production volume of each period. The economic problem would be the determination of the allocation and the price level consistent with equilibrium adjustments.

Under conditions of surplus production and effective price support programs (representative of a perfectly elastic government demand at the effective price support level) the residual economic problem for private industry would be the equilibrium allocation among livestock classes at the fixed price level. If total supply is also considered fixed, the allocation to government demand is also determinable.

One is faced with a complex problem in deciding which cost factors are consistent with short-run analyses of the livestock-feed economy. The value productivity functions for beef, pork, and broilers have separated conversion costs into feed cost and other costs. Differences in individual unit efficiency and costs are ignored. For a single short-run period, one may assume that cost coverage should equal or exceed direct costs, but continuous application of this viewpoint at the minimum level could only lead to sequential bankruptcy in practice and to unreasonable comparative values for a series of periods involved in
a historical appraisal. A continuous full cost basis for equilibrium computations to be compared with actual historical performance appears to be more logical than the conventional basis for a single point in time. Furthermore, the problems of the delineation of relevant variable costs and the heterogeneity of the industry lead to no other practical course of action.

Finally, because of the length of the average feeding program for beef cattle, the predetermined inventory of feeder animals, and some inflexibility in the technical properties of carcasses acceptable to the marketing sector, one might postulate that beef production and consequently the use of feed concentrate in finishing beef are fixed in the short period. This would leave only the swine and broiler sectors with an assumed flexibility in the short run. If feed concentrate use by the beef sector is not considered predetermined, then the beef finishing operations would also represent an adjustable sector.

To illustrate the structure of the short-run demand and value determination system for feed concentrates when certain combinations of the criteria discussed above are imposed, we shall select the years 1950 (to represent an open market period) and 1959 (to represent a price support period).

1950 Short-run Situations

(1) Data assumed predetermined or fixed.

- Beef base (B) = 7,236.06 million pounds (retail weight)
- Hen base (C) = 992.10 million pounds (retail weight)
- Farm raised chickens (F) = 771.76 million pounds (retail weight)

\[
\begin{align*}
Q_6 &= 57,184 \text{ million pounds} \\
Q &= 290,000 \text{ million pounds} \\
X_9 &= $1,369 \\
X_{10} &= $1.34 \\
X_8 &= 6.1 \text{ pounds per capita} \\
Q_4 &= 4,307.42 \text{ million pounds (based on } N \text{ and } X_9) \\
Q_5 &= 37,933.39 \text{ million pounds (based on } N \text{ and } X_8) \\
Q_6 &= 17,521.35 \text{ million pounds (based on } N \text{ and } X_6 = 350) \\
Q_7 &= 18,975.80 \text{ million pounds (based on } N \text{ and } X_8) \\
N &= 151.7 \text{ million persons} \\
Q_3^0 &= 6,559.96 \text{ million pounds of feed concentrate for farm raised chickens produced. (Batch commitments are made early in period—so assumed fixed.)}
\end{align*}
\]

The value of B = 7,236.06 is an estimated value from ex post data. Actual use of feed concentrates in finishing beef is estimated as the residual between total use in the seven categories (Q - Q_3^0) and esti-

---

6 Feed conversion factors relevant for 1950 differ from those previously listed for 1959 only for chickens and hens. They are 3.95:1 broilers, 5.95:1 farm raised chickens, and 7.7:1 eggs. The value productivity function for broilers is consistently, \( P_6^* = 2.63 \) \( P + 16.60 \).
mated actual use in $Q_2$ through $Q_7$. This use is converted to retail beef equivalent and subtracted from the total supply (consumption) of beef. The difference is the beef base, $B$.

The value 771.76 for farm raised chicken meat and the feed equivalent $Q_3^c = 6,559.96$ are estimated values. They are based on an estimated total production and the portions of supply made up from the broiler and hen culling operations in 1950. Therefore, farm raised chicken meat is equal to $N X_3 - C$ (broiler production).

The values for $Q_4$, $Q_5$, $Q_6$, $Q_7$ listed above are not estimated actual feed usages in 1950, but estimated average equilibrium values for 1950 based on population size $N$ and listed values for $X_9$ and $X_8$. Actual ex post values for $Q_4$, $Q_5$, $Q_6$, $Q_7$ differed slightly (randomly) from the values indicated above.

(a) Full cost coverage equilibrium (beef finishing flexible)

$$Q_1 = 103,246.02 - 19,754.26 P$$
$$Q_2 = 103,704.24 - 3,972.92 P$$
$$Q_3 = Q_3^c + 6,790.39 + 797.92 P$$
$$= 13,350.35 + 797.92 P$$

$$Q = Q_0 + \sum_{i=1}^{7} Q_i$$

$$= 57,184.00 + 299,038.57 - 22,929.26 P$$
$$= 356,222.57 - 22,929.26 P$$

Setting $Q = 290,000$ and solving for $P$, we secure $P = 2.89$ cents per pound. Substituting this value for $P$ into the functions $Q_1$, $Q_2$, and $Q_3$ above results in the equilibrium allocations

$Q_1 = 46,156$ (actual estimated usage 45,510)
$Q_2 = 92,223$ (actual estimated usage 93,729)
$Q_3 = 15,656$ (actual estimated usage 14,231)

(b) Full cost coverage equilibrium (beef finishing fixed)

This case is similar to (a) except that total beef supply is assumed fixed at the actual magnitude of 10,831.38 million pounds and is equal to the beef base of 7,236.06 million pounds and the feedlot conversion of 3,595.32 million pounds. The latter is equivalent to 45,510.41 million pounds of feed concentrate and fixes $Q_1$ at that magnitude. The demand functions for pork and broilers are converted to reflect the fixed supply of beef—this condition is also reflected in the derived demand functions for feed concentrates $Q_2$ and $Q_3$. Only the swine and broiler producing sectors are considered capable of flexible adjustment.\(^7\)

Results are as follows:

\(^7\)This refers to price dependent sectors. In all cases the turkey, egg, and milk sectors are assumed to be capable of full adjustment to their price inelastic and short-period, fixed demands.
\[ Q_1 = 45,510.41 \text{ (fixed)} \]
\[ Q_2 = 117,080.26 - 8,569.29 P \]
\[ Q_3 = Q_3^{\text{eq}} + 9,751.60 - 230.67 P \]
\[ = 16,311.56 - 230.67 P \]

\[ Q = Q_0 + \sum_{i=1}^{7} Q_i \]
\[ = 314,824.19 - 8,799.96 P \]

\[ P = 2.82 \text{ cents per pound when } Q = 290,000 \text{ million pounds.} \]

Allocations for \( Q_2 \) and \( Q_3 \) are:
\[ Q_2 = 92,915 \]
\[ Q_3 = 15,661 \]

Notice that these results are similar to those in (a), as would be expected since the fixed value of \( Q_1 \) at 45,510.41 is very near to the equilibrium value of 46,156 computed in (a). Observe also that the conditional demand function for \( Q_2 \) has become more elastic with respect to price (as should be expected when beef supply is assumed fixed) and that the price coefficient of \( Q_3 \) has shifted from a positive value in (a) to a negative value in (b) for the same reason. In part (a) the price coefficient in \( Q_1 \) (and consequently in \( Q \)) is much larger than would exist under long-run conditions when the beef base would be a flexible component of beef supply (but in a fixed proportion to the total). This means that if the beef base is near the long-run equilibrium level, then the short-run (intraannual) price elasticity for feed grain demand is greater than the long-run (interannual) elasticity in the static case.

The actual price of corn was 2.23 cents per pound in 1950. Contrast this with an imputed equilibrium value of 2.89 cents per pound in part (a) and 2.82 cents per pound in part (b). Some utilization divergence in beef, pork and broiler operations was indicated. Actual operations in 1950 could have been earning excess profits or suffering some losses. From the utilization divergences, one would suspect that the beef and broiler operations were realizing returns for feed conversion greater than market price and that the swine operation was either acting as the marginal valuation sector (just covering costs) or was suffering some loss over full cost coverage when corn had an open market value of 2.23 cents per pound. Taking the livestock prices \( P_1' = 29.36, P_2' = 19.49, \) and \( P_3' = 27.4 \) we find that the imputed productivity values for feed concentrates were \( P_1^* = 2.89, P_2^* = 2.46, \) and \( P_3^* = 4.11 \) cents per pound. Although these results support the suggested explanation, all are greater than 2.23. One might conclude that cash sales are heavily weighted with distress conditions and could be the explanation of the depressed market price. However, it is doubtful that the use of average estimated functional relations in the quantified model could ever explain the unique divergences at one point in
time. It is rather amazing that the results are as consistent as they appear to be in an ordered sense.

Finally, the small differences in the results between parts (a) and (b) do not support a preference for the acceptance or rejection of the fixed beef supply short-run condition. With numerous continuous feedlot operations in existence, the logical conclusion would be in support of a flexible intraannual beef finishing condition.

1959 Short-run Situations

(1) Data assumed predetermined or fixed.

\[
\begin{align*}
B &= 9,148.18 \text{ million pounds} \\
C &= 887.31 \text{ million pounds} \\
F &= 175.29 \text{ million pounds} \\
Q_0 &= 66,140 \text{ million pounds} \\
P &= 1.93 \text{ cents per pound} \\
X_9 &= 1,893 \\
X_{10} &= 2.06 \\
X_s &= 9.2 \text{ pounds per capita} \\
Q_4 &= 7,722.53 \text{ million pounds} \\
Q_5 &= 36,626.97 \text{ million pounds} \\
Q_6 &= 20,455.05 \text{ million pounds} \\
Q_7 &= 19,734.95 \text{ million pounds} \\
N &= 177.1 \text{ million persons} \\
Q_3 &= 1,377.28 \text{ million pounds} \\
Q_1 &= 78,786.13 \text{ million pounds (fixed for part (b))} \\
\end{align*}
\]

(a) Full cost coverage equilibrium (beef finishing flexible)

\[
\begin{align*}
Q_1 &= 143,065.70 - 23,061.83 P \\
Q_2 &= 110,115.66 - 4,638.13 P \\
Q_3 &= 17,100.09 + 939.40 P \\
Q &= 420,960.95 - 26,760.56 P \\
\end{align*}
\]

Under the 1959 situation we assume that P is fixed (not the utilization) and compute the equilibrium utilization and its allocation. If the current production level exceeded commercial demand at P = 1.93 then the excess would be allocated to surplus storage. Some surplus storage stocks would be demanded if current production were short of commercial demand.

Substituting P = 1.93 into the demand functions results in:

\[
\begin{align*}
Q_1 &= 98,556 \text{ (actual estimated usage 78,786)} \\
Q_2 &= 101,641 \text{ (actual estimated usage 105,944)} \\
Q_3 &= 18,913 \text{ (actual estimated usage 22,452)} \\
Q &= 369,313 \text{ (actual estimated usage 357,600)} \\
\end{align*}
\]

These results suggest that total commercial use should have been larger than realized, with a large increase in feed use in finishing beef
and a reduction in feed use for swine and broilers. Computed grain value productivities for 1959 are $P_1^* = 2.62$, $P_2^* = 1.58$ and $P_3^*$ is negative if other costs are covered and equal to 1.75 cents per pound if nonfeed costs are not covered. Compared with a market value of 1.93 cents per pound, these values are in accord with the utilization differences.

(b) Full cost coverage equilibrium (beef finishing fixed)

\[
\begin{align*}
Q_1 &= 78,768.13 \text{ million pounds (fixed)} \\
Q_2 &= 124,972.08 - 10,004.09 P \\
Q_3 &= 20,053.76 - 127.49 P \\
Q &= 374,473.46 - 10,131.58 P \\
\end{align*}
\]

When the value for $P$ of 1.93 is substituted into these demand functions we secure:

\[
\begin{align*}
Q_2 &= 105,664 \\
Q_3 &= 19,808 \\
Q &= 354,920 \\
\end{align*}
\]

Under these conditions, equilibrium total usage should have been about 2,700 smaller than actual use and nearly all of this should have been in a reduction in broiler production. These results are more nearly in accord with activities in 1959, but again it is questionable that the assumption of a fixed short period beef finishing operation is clearly preferable to the assumption of a flexible feedlot operation.

**A HISTORICAL APPRAISAL FOR THE 1949-59 PERIOD**

The latter part of the previous section indicated a few specific ways in which equilibrium adjustments could be estimated for the short time period. The treatment of the 1950 calendar year situation (consumer demand is related to the calendar year—feed production and use is lagged three months to reflect the October to October crop year) was on an open market basis with total use and carryover considered fixed. The issue was the determination of the equilibrium allocation of the feed to animal classes and the determination of the price level. Although under the assumptions, this was a useful illustration of efficiency analysis, the treatment of the carryover determination (and therefore the level of use) was not very realistic. The discussion of the 1959 situation was more appropriate, but the question of price level to be assumed fixed was somewhat arbitrary. Instead of the open market price received by farmers ($1.93 per cwt.) perhaps the choice should have been the estimated effective loan rate of about $2.29 per hundredweight for program compliers.

Feed grain production for the 1947 crop year was only 94.1 million tons and by the time the bumper 1948 corn crop was to be harvested
the carry-in had been reduced to only 7.8 million tons—much lower than normal. The national support price on corn for the 1948 crop was about $2.57 per hundredweight and with an estimated discount of 14 cents per hundredweight would produce an estimated effective support price of $2.43 per hundredweight. Concentrates fed during this crop year were 120.1 million tons of which 110.219 million tons were estimated as having been fed to those categories considered specifically in this study. We assume the "other uses" category fixed at 26.381 million tons, with total use for the year of 136.6 million tons. A carryover increase amounted to 22.6 million tons.

If we analyze the 1949 calendar year problem in the same manner as for 1950 under the "beef finishing flexible" assumption, we estimate an achievable value for feed concentrates of $2.70 per hundredweight. This is 53 cents above the price received by farmers and about 27 cents above the effective support price. Equilibrium carryover would not be as large as the value of 30.4 million tons realized, if a better allocation between livestock classes had been achieved and the total use expanded so that the value productivity of 2.70 cents per pound had been driven down to the effective support price of 2.43 cents per pound.

Equilibrium utilization at 2.43 cents per pound would be estimated at 139.05 million tons or an increase of 3.05 million tons, providing an equivalent reduction in carryout. We assume that this would all be taken from C.C.C. stocks and that "other" carryout would not be affected. We will further assume that a minimum disposal price of 105 percent of the actual support price at time of release would be the release rule for these stocks and that release at lower prices because of deterioration would be negligible. The carrying charge will be absorbed by C.C.C. as a public cost to be partially offset by the surplus return on some disposed volumes.

As it turns out, the impact of the price support program in conjunction with demand and production levels only permit carryover to be reduced to levels near what might be considered "open market" determined for the 1950 and 1951 crop years. To avoid the problem of developing a reservation demand function for utilization and carryover determination, it will be assumed that the release price of $2.75 per hundredweight would be the equilibrium price for the 1950 crop, and that the actual total use of the 1951 crop would be of equilibrium magnitude.

The previous paragraphs give some indication of the procedure which will be used to estimate an equilibrium adjustment path (period by period with carryover determination) for the feed concentrate economy during the 1949-59 period. Certain conditional assumptions which underlie this sequential estimating process will be given. Others that are obvious in the tabled results will be left unstated.

1. Assumptions given in the earlier short-period appraisal for 1950 (except for the fixed total utilization assumption) will be con-
sistantly changed year by year. The flexible beef finishing as-
sumption will be used. Conversion factors will be altered for
chickens, and hens as indicated later in the 1949-59 dynamic
analysis.

2. No change is assumed for the price support series. Effective loan
rates will be 14 cents per hundredweight below the announced
rates. Although actual realized loan rates were generally lower
than announced rates, this resulted mostly from locational differ-
entials which will be assumed to parallel open price differentials.
Consequently, the U. S. announced rate will be the basis for
values to be consistent with the use of an aggregated U. S. aver-
age price in the model. The 105 percent rule will be the release
rule for C.C.C. stocks.

3. Production of feed grains would not be altered by a revised path
for use and prices. Only feed grain carryover will be considered.
The supply and use of other feed concentrates will be assumed
to remain unchanged at realized magnitudes. "Other stocks" vol-
umes would not be altered except for the 1950 through 1952
crop years.

4. Equilibrium results assume equal values in alternative uses and
an equivalent open market price. No depressed sector (or open
market price) can occur.

5. Computed results will be stated in terms of millions of pounds
and dollars per hundredweight. Actual historical values will be
similarly converted.

Table 2 shows various actual and imputed prices (or values) that
are basic to the historical appraisal of the 1949-59 period. The first
column gives the imputed values per hundredweight for feed concen-
trates if the actual total amount fed to the seven categories considered
previously were allocated in equilibrium volumes. The second column
gives the announced U. S. average support prices, converted to dollars
per hundredweight. The third column is an estimate of the effective
net prices to farmers from price support loans. The fourth column is
the computed release prices for disposal at concurrent support prices.
For comparative purposes the last column shows the U. S. average
prices received by farmers for corn. Corn price will be the only feed
grain price employed as the indicator of feed concentrate values.

By reference to the values in Table 2, we can follow the equilibrium
path for the results in Table 3. Entering the 1948 crop year, a total
supply of 334,000 million pounds of feed were available for use and
carryover. If 220,438 million pounds were used in equilibrium, an
imputed value of $2.70 per hundredweight should have been realized.
However, if a carryover of only 30,200 million pounds of "other stocks"
is to materialize without an accumulation of C.C.C. holdings, the price
level would have to drop far below the effective support price of $2.43
### Table 2. Actual and Imputed Corn Values in the U. S., 1948-58,
in dollars per hundredweight

<table>
<thead>
<tr>
<th>Crop year</th>
<th>Conditional Equilibrium Value</th>
<th>National Support Price</th>
<th>Estimate of Net Support Price</th>
<th>Computed Release Price</th>
<th>Price Received by Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>2.70</td>
<td>2.57</td>
<td>2.43</td>
<td>2.70</td>
<td>2.17</td>
</tr>
<tr>
<td>1949</td>
<td>2.85d</td>
<td>2.50</td>
<td>2.36</td>
<td>2.62</td>
<td>2.23</td>
</tr>
<tr>
<td>1950</td>
<td>3.07</td>
<td>2.62</td>
<td>2.48</td>
<td>2.75</td>
<td>2.79</td>
</tr>
<tr>
<td>1951</td>
<td>2.28</td>
<td>2.86</td>
<td>2.66</td>
<td>2.94</td>
<td>3.00</td>
</tr>
<tr>
<td>1952</td>
<td>2.09</td>
<td>2.86</td>
<td>2.72</td>
<td>3.00</td>
<td>2.63</td>
</tr>
<tr>
<td>1953</td>
<td>1.83</td>
<td>2.89</td>
<td>2.75</td>
<td>3.00</td>
<td>2.80</td>
</tr>
<tr>
<td>1954</td>
<td>1.55</td>
<td>2.82</td>
<td>2.68</td>
<td>2.96</td>
<td>2.45</td>
</tr>
<tr>
<td>1955</td>
<td>2.14</td>
<td>2.68</td>
<td>2.54</td>
<td>2.81</td>
<td>2.16</td>
</tr>
<tr>
<td>1956</td>
<td>2.59</td>
<td>2.50</td>
<td>2.36</td>
<td>2.62</td>
<td>1.92</td>
</tr>
<tr>
<td>1957</td>
<td>2.33</td>
<td>2.43</td>
<td>2.29</td>
<td>2.55</td>
<td>1.93</td>
</tr>
</tbody>
</table>

---

a Computed from equilibrium demand function for each year at a quantity level equal to actual usage.
b 14 cents less than support level.
c 105 percent of support level.
d Due to minor rounding errors this value is slightly different from the value of $2.89 computed in the previous analysis of the 1950 short-period.

With full reaction and a sufficient volume of compliance feed, the equilibrium price would be the effective support value. At that value level, 226,539 million pounds could be used in equilibrium by the commercial sector and a carryover of 54,699 million pounds, of which 24,499 million pounds would be in C.C.C. stocks, would materialize.

The 1949 crop year situation shows that the imputed value of $2.85 for the conditional equilibrium is above the C.C.C. release price of $2.62 (from '48 stocks). This means that releases can be made and the equilibrium price (value) for that year would be $2.62 per hundredweight. The actual releases will be assumed to come from “other stocks” on the assumption that the government would pass the opportunity to the trade.

Consideration of the 1950 crop year leads to the conclusion that the release price of $2.75 would be the equilibrium value. All C.C.C. stocks and a part of the other stocks could be absorbed. The 1951 crop year was treated as an open market situation, and although private stocks were drawn to a low point by assuming actual utilization to be equilibrium utilization, the value of a more logical determination of the carryover would have had little effect on the subsequent year estimates. The equilibrium price would have been $3.07.

Beginning in the 1952 crop year, the estimated effective support prices were the selected equilibrium values for all the subsequent years. Utilization was calculated at these price levels and the carryover computed. The allocation of the carryover between private and C.C.C. stocks was made on the basis that experienced private stocks would not be affected. We should observe that the estimated equilibrium...
Table 3. U. S. Feed Concentrate Supply and Utilization, Stated in Millions of Pounds
(Upper figures are actual data)
(Lower figures are estimated equilibrium values)

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Carryover of Feed Grains</th>
<th>Feed Grain Production</th>
<th>Other Grains and By-Products Used</th>
<th>Total Supply</th>
<th>Concentrates Used in Categories Specified</th>
<th>Other Uses of Feed Concentrates</th>
<th>Total Utilization of Feed Concentrates</th>
<th>Estimated Equilibrium Price (Dollars per cwt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under Price Supports</td>
<td>Other Stocks</td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>...</td>
<td>15,600</td>
<td>15,600</td>
<td>270,800</td>
<td>47,600</td>
<td>334,000</td>
<td>220,438</td>
<td>52,762</td>
</tr>
<tr>
<td>1949</td>
<td>30,600</td>
<td>30,200</td>
<td>60,800</td>
<td>240,000</td>
<td>50,000</td>
<td>350,800</td>
<td>232,816</td>
<td>57,184</td>
</tr>
<tr>
<td>1950</td>
<td>41,800</td>
<td>19,200</td>
<td>61,000</td>
<td>243,600</td>
<td>53,000</td>
<td>357,600</td>
<td>241,438</td>
<td>58,962</td>
</tr>
<tr>
<td>1951</td>
<td>29,600</td>
<td>27,600</td>
<td>57,200</td>
<td>226,200</td>
<td>55,000</td>
<td>338,400</td>
<td>245,886</td>
<td>52,314</td>
</tr>
<tr>
<td>1952</td>
<td>18,000</td>
<td>22,200</td>
<td>40,200</td>
<td>239,400</td>
<td>55,800</td>
<td>335,400</td>
<td>226,900</td>
<td>53,300</td>
</tr>
<tr>
<td>1953</td>
<td>33,200</td>
<td>20,800</td>
<td>54,000</td>
<td>235,000</td>
<td>55,400</td>
<td>344,400</td>
<td>233,376</td>
<td>48,224</td>
</tr>
<tr>
<td>1954</td>
<td>12,941</td>
<td>33,741</td>
<td></td>
<td></td>
<td></td>
<td>324,141</td>
<td>217,911</td>
<td></td>
</tr>
<tr>
<td>1955</td>
<td>45,200</td>
<td>18,200</td>
<td>63,400</td>
<td>247,800</td>
<td>52,200</td>
<td>363,400</td>
<td>235,026</td>
<td>50,774</td>
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<tr>
<td>1956</td>
<td>39,796</td>
<td>58,006</td>
<td></td>
<td></td>
<td></td>
<td>358,006</td>
<td>212,150</td>
<td></td>
</tr>
<tr>
<td>1957</td>
<td>59,400</td>
<td>18,800</td>
<td>78,200</td>
<td>261,800</td>
<td>53,800</td>
<td>393,800</td>
<td>247,542</td>
<td>59,658</td>
</tr>
<tr>
<td>1958</td>
<td>76,202</td>
<td>95,082</td>
<td></td>
<td></td>
<td></td>
<td>410,682</td>
<td>218,919</td>
<td></td>
</tr>
<tr>
<td>1959</td>
<td>69,400</td>
<td>17,200</td>
<td>86,600</td>
<td>260,400</td>
<td>54,000</td>
<td>401,000</td>
<td>244,822</td>
<td>58,378</td>
</tr>
<tr>
<td></td>
<td>114,905</td>
<td>132,105</td>
<td></td>
<td></td>
<td></td>
<td>446,505</td>
<td>234,426</td>
<td></td>
</tr>
<tr>
<td>1956</td>
<td>81,600</td>
<td>16,200</td>
<td>97,800</td>
<td>285,800</td>
<td>57,000</td>
<td>440,600</td>
<td>263,576</td>
<td>58,824</td>
</tr>
<tr>
<td>1957</td>
<td>137,501</td>
<td>153,701</td>
<td></td>
<td></td>
<td></td>
<td>496,501</td>
<td>269,524</td>
<td></td>
</tr>
<tr>
<td>1958</td>
<td>98,400</td>
<td>19,800</td>
<td>118,200</td>
<td>315,200</td>
<td>59,600</td>
<td>493,000</td>
<td>291,460</td>
<td>66,140</td>
</tr>
<tr>
<td>1959</td>
<td>114,000</td>
<td>20,000</td>
<td>134,000</td>
<td></td>
<td></td>
<td>542,953</td>
<td>292,453</td>
<td></td>
</tr>
<tr>
<td></td>
<td>164,360</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
holdings of C.C.C. at the beginning of the 1959 crop year would be almost 50 percent higher than were actually held. This would amount to 50,360 million pounds or 25.2 million tons.

These results indicate that farmers underused feed grains for the crop years 1948 through 1950, overused feed from 1952 through 1956 crop years, and underused feed during crop years 1957 and 1958. The respective magnitudes were approximately $-32,000, 58,000$ and $-7,000$ million pounds. This amounts to a net overuse of about 19,000 million pounds for the entire period. Relative use in this context has reference to the difference between actual use and estimated equilibrium utilization in the situation of a price support alternative. In a net accounting sense, this “overuse” produced (1) lower returns to farmers, (2) lower food prices for meat and other animal products, (3) a significantly lower outlay by C.C.C. in price support loans and purchases, and (4) a sizeable reduction in carrying costs for storage stocks, over what has been computed as an equilibrium response by feed grain producers to the price support program. Considering recent C.C.C. holdings as representative of “hard” surplus stocks, farmers absorbed about one-third of the surplus output of feed grains (since the 1951 crop year), giving consumers a sizeable reduction in food costs and significant savings in federal expenditures.

The imputed impact of the cattle cycle is also apparent. The large equilibrium demands for feed concentrates for crop years 1948 through 1951, the reduced demand levels for crop years 1952 through 1956, and the rising demand levels for crop years 1957 and 1958 are an inverse reflection of the low and high and low periods of the cattle cycle. This factor cannot be ignored when one considers an orderly supply rate for feed grain production.

Simultaneous with disequilibrium total use of feed concentrates, a situation of inconsistent use between livestock classes occurs. When one considers the industry with all the elements of imperfect knowledge and time lags between decisions and results, a certain degree of disequilibrium is inevitable. The equilibrium model should be visualized as an abstract (ex post) norm against which performance can be measured. It is not possible to postulate what measure of random variation from this norm is the achievable optimum. Nevertheless, the norm is a basis toward which actual performance should tend in an efficiency context.

Table 4 presents the details of actual and estimated equilibrium utilization of feed concentrates by animal classes. The “actual” data are not directly available. The values given are estimates based on the conversion of reported production (consumption) of products into their feed equivalent. The use in finishing beef is estimated as a residual from reported total use and the estimated total use by the other classes of animals and “other uses.” Variation between actual and equilibrium values for turkey, egg, and milk utilization of feed
Table 4. U. S. Feed Concentrate Use by Animal Classes (Millions of Pounds)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>Actual</td>
<td>40,034</td>
<td>45,510</td>
<td>47,952</td>
<td>48,990</td>
<td>42,001</td>
<td>49,389</td>
<td>40,773</td>
<td>46,861</td>
<td>50,689</td>
<td>65,628</td>
<td>78,786</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>40,063</td>
<td>51,181</td>
<td>74,851</td>
<td>58,561</td>
<td>26,411</td>
<td>25,912</td>
<td>18,873</td>
<td>23,776</td>
<td>36,687</td>
<td>68,941</td>
<td>89,748</td>
</tr>
<tr>
<td>Pork</td>
<td>Actual</td>
<td>90,186</td>
<td>93,729</td>
<td>99,119</td>
<td>101,489</td>
<td>90,488</td>
<td>87,000</td>
<td>98,590</td>
<td>101,220</td>
<td>94,007</td>
<td>94,519</td>
<td>105,944</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>93,413</td>
<td>92,874</td>
<td>92,385</td>
<td>91,644</td>
<td>93,465</td>
<td>94,744</td>
<td>94,989</td>
<td>95,500</td>
<td>97,329</td>
<td>98,604</td>
<td>99,039</td>
</tr>
<tr>
<td>Chicken</td>
<td>Actual</td>
<td>13,378</td>
<td>14,231</td>
<td>14,834</td>
<td>15,504</td>
<td>15,188</td>
<td>16,222</td>
<td>14,318</td>
<td>17,354</td>
<td>18,140</td>
<td>20,888</td>
<td>22,455</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>14,666</td>
<td>15,378</td>
<td>15,799</td>
<td>16,778</td>
<td>16,812</td>
<td>17,202</td>
<td>17,275</td>
<td>17,809</td>
<td>18,106</td>
<td>18,479</td>
<td>19,164</td>
</tr>
<tr>
<td>Turkey</td>
<td>Actual</td>
<td>3,517</td>
<td>4,493</td>
<td>4,853</td>
<td>5,270</td>
<td>5,472</td>
<td>6,148</td>
<td>5,832</td>
<td>6,247</td>
<td>7,215</td>
<td>7,225</td>
<td>7,590</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>3,812</td>
<td>4,307</td>
<td>4,855</td>
<td>5,146</td>
<td>5,518</td>
<td>5,615</td>
<td>6,095</td>
<td>6,597</td>
<td>6,993</td>
<td>7,225</td>
<td>7,722</td>
</tr>
<tr>
<td>Eggs</td>
<td>Actual</td>
<td>37,183</td>
<td>37,828</td>
<td>38,249</td>
<td>38,365</td>
<td>37,358</td>
<td>37,103</td>
<td>36,747</td>
<td>36,622</td>
<td>35,677</td>
<td>35,490</td>
<td>36,535</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>38,492</td>
<td>37,895</td>
<td>37,299</td>
<td>37,338</td>
<td>36,984</td>
<td>37,084</td>
<td>36,784</td>
<td>36,252</td>
<td>36,007</td>
<td>36,544</td>
<td>36,590</td>
</tr>
<tr>
<td>Fluid Milk</td>
<td>Actual</td>
<td>17,331</td>
<td>17,471</td>
<td>17,935</td>
<td>18,237</td>
<td>18,328</td>
<td>18,650</td>
<td>19,201</td>
<td>19,649</td>
<td>19,774</td>
<td>19,855</td>
<td>20,338</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>17,233</td>
<td>17,521</td>
<td>17,833</td>
<td>18,134</td>
<td>18,434</td>
<td>18,757</td>
<td>19,092</td>
<td>19,427</td>
<td>19,774</td>
<td>20,143</td>
<td>20,455</td>
</tr>
<tr>
<td>Manuf. Milk</td>
<td>Actual</td>
<td>18,808</td>
<td>19,624</td>
<td>18,496</td>
<td>18,080</td>
<td>18,065</td>
<td>18,864</td>
<td>19,365</td>
<td>19,594</td>
<td>19,322</td>
<td>19,971</td>
<td>19,812</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>18,860</td>
<td>18,976</td>
<td>18,974</td>
<td>18,394</td>
<td>18,558</td>
<td>18,598</td>
<td>19,148</td>
<td>19,558</td>
<td>19,530</td>
<td>19,588</td>
<td>19,735</td>
</tr>
</tbody>
</table>

* Calendar years
concentrates merely reflects the differences between actual and estimated per capita demand for the products. Similar variation for beef, pork, and chicken reflect movement from price disequilibrium to equilibrium for value productivities for feed as well as some minor random variation between observed and estimated data underlying demand functions. The information in Table 4 needs little elaboration beyond what has been stated. As would be expected, the deviations are greatest for the price dependent sectors, beef, pork, and chickens. Note the effect of the cattle cycle on the demand for feed concentrates to meet beef demand.

Finally, we should compute the imputed values for feed concentrates under the actual performance of the industry for the 1949-59 period. This will be done for beef, pork, and broiler production—the other uses which are considered to be price independent will not be covered, even though such value productivity functions could be estimated. Since they were not required for the basic study, they will not be considered here. Simply stated, the procedure of imputation will take the live animal prices as given and upon substitution in the previously developed productivity functions will produce the required estimates. Table 5 presents these results. Actual prices received by farmers for corn and the estimated equilibrium prices for the period are also presented for comparative purposes. One can contrast these values and check against the utilization shifts indicated in Table 4 for consistency. One can also check these values against the “well” and “sick” periods of feeding these animal classes since 1949. It should be recognized that feed costs represent about 55 percent of beef finishing costs, 70 percent of hog supply cost, and only about 25 percent of broiler costs when the latter operation uses prepared mash involving a relatively large “fixed” cost component independent of variations in feed grain prices.

The important point to be understood from the information in Table 5 is that various values exist for the “price” of feed concentrates at points in time. The price received by farmers as reported is only one of these and may be above, but most likely below, some use value. Consequently, the use of the prices received by farmers to evaluate income received by farmers for using feed (in general, feed is an intermediate product—not a terminal product) is at best an approximation. It should be evident that the market for feed grains is not such that open market sales and use values are maintained in equality.

We shall now turn to a temporal analysis of long-run trends in the demand structure for feed concentrates.

**Feed Concentrate Demand Structure—Dynamic Aspects**

This section is devoted to a semi-dynamic analysis of the effects of population growth, income and marketing cost trends, and improved rates of feed conversion on the derived demand for feed concentrates.
Table 5. Various Prices and Imputed Value Productivities for Feed Concentrates, in Dollars per Hundredweight (U. S. Annual Averages)

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Price Received by Farmers</th>
<th>Imputed for Beef Finishing</th>
<th>Imputed for Hog Production</th>
<th>Imputed for Broiler Production</th>
<th>Estimated Equilibrium Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( P )</td>
<td>( P_1^* )</td>
<td>( P_2^* )</td>
<td>( P_3^* )</td>
<td></td>
</tr>
<tr>
<td>1949</td>
<td>2.17</td>
<td>2.36</td>
<td>2.49</td>
<td>4.39</td>
<td>2.43</td>
</tr>
<tr>
<td>1950</td>
<td>2.23</td>
<td>2.89</td>
<td>2.46</td>
<td>4.11</td>
<td>2.62</td>
</tr>
<tr>
<td>1951</td>
<td>2.79</td>
<td>3.86</td>
<td>2.76</td>
<td>4.55</td>
<td>2.75</td>
</tr>
<tr>
<td>1952</td>
<td>3.00</td>
<td>3.42</td>
<td>2.35</td>
<td>4.70</td>
<td>3.07</td>
</tr>
<tr>
<td>1953</td>
<td>2.63</td>
<td>1.92</td>
<td>3.13</td>
<td>4.06</td>
<td>2.72</td>
</tr>
<tr>
<td>1954</td>
<td>2.80</td>
<td>1.97</td>
<td>3.23</td>
<td>2.47</td>
<td>2.72</td>
</tr>
<tr>
<td>1955</td>
<td>2.45</td>
<td>1.84</td>
<td>1.82</td>
<td>3.33</td>
<td>2.75</td>
</tr>
<tr>
<td>1956</td>
<td>2.28</td>
<td>1.66</td>
<td>1.65</td>
<td>1.04</td>
<td>2.68</td>
</tr>
<tr>
<td>1957</td>
<td>2.16</td>
<td>1.87</td>
<td>2.33</td>
<td>.75</td>
<td>2.54</td>
</tr>
<tr>
<td>1958</td>
<td>1.92</td>
<td>2.53</td>
<td>2.73</td>
<td>.58</td>
<td>2.36</td>
</tr>
<tr>
<td>1959</td>
<td>1.93</td>
<td>2.62</td>
<td>1.58</td>
<td>-.44</td>
<td>2.29</td>
</tr>
</tbody>
</table>

\( a \) From Table 3.

No other factors will be considered. Based on data for 1954-59, the following trend functions have been estimated with \( t = 0 \) in 1945:

**Population (N)**

\[
\log N_t = 2.173521 + .007483 t \\
(r = .9986)
\]

Converted to,

\[
N_t = (149.1) (1.0174)^t.
\]

Notice the high correlation coefficient and that the value 149.1 (representing \( N_0 \)) is very near to the actual population figure for 1949 of 149.2 million.

**Per Capita Disposable Income (X9)**

\[
X_{9t} = 1319.045420 + 58.190916 t \\
(2.74)
(r = .990)
\]

**Wage Rate of Food Distribution Employees (X10)**

\[
X_{10t} = 1.272555 + .078364 t \\
(0.007)
(r = .9996)
\]

**Per Capita Margarine Consumption (X8)**

\[
X_{8t} = 6.231823 + .319090 t \\
(.115)
(r = .921)
\]

**Annual Laying Rate per Hen—Dozens of Eggs (r5)**

\[
r_{5t} = 14.196971 + .293939 t \\
(.005)
(r = .9988)
\]
These relationships will be used not only as descriptive of the 1949-59 period, but also projective for the near future for these exogenous variables.

Many forms of technological change pervade the livestock-feed economy. We shall consider only those that have an impact on physical conversion rates for feed into animal products. Changing conversion rates influence the derived demand for feed concentrates in two primary ways, namely, (1) alter the physical conversion factors and (2) alter the value productivity functions in the value dimension. The second feature is relevant only for the price dependent sectors of demand.

Changing conversion rates would usually affect the value productivity functions in two ways. Consider the general linear productivity function, \( P'_{it} = AP_{it}^* + B \), where \( P_{it}^* \) would be value per pound for the \( i^{th} \) animal product, \( P_{it}^* \) would be the value per pound for feed concentrate, \( A \) would be the conversion rate, and \( B \) would be the other costs of production per unit of product. Normally, a change in the conversion rate would be reflected directly in the value of \( A \) and indirectly (but in the same direction) in the value of \( B \). Because of the difficulty of specifying the change in \( B \) without intense study of the specific case, we will assume that changing conversion rates for feed have no influence on the nonfeed unit costs of production. This is a conservative position that exaggerates slightly the decline in demand caused by improved conversion rates.

Except for the geometric growth rate indicated for population, \( N \), all other trends will be analyzed in linear form. This simplifies the work and interpretation of the results, and is reasonable for short period considerations. Nonlinear trends create no logical barriers to their use.

The general model will be worked out using arbitrary constants for the trend functions. This will permit us to make a general interpretation of the results. Upon the substitution of specific values for these constants we can appraise the separate and combined effects of changes during the 1949-59 period or the effects of any potential changes we may wish to consider. The only requirement for projective use is that the base point for time be adjusted to the common point of reference for projected changes. Long-run conditions will be assumed throughout.

The basic demand model is as follows:

\[
Q_{ot} = K_t, \text{ assumed a fixed constant for analysis of the 1949-59 period.}
\]

\[
Q_{1t} = \frac{c_{1t}}{k_1} \left[ N_t X_{1t} - B_t \right], \text{ where } c_{1t} \text{ is the feed concentrate conversion rate for beef finishing operations and } k_1 \text{ is the processing}
\]

\footnote{For the beef finishing operation, \( A \) would not represent the conversion rate because of the feeder animal influence on this parameter. For conditions stated in this report, \( A \) would be 87 percent of the conversion rate.}
conversion rate from live to carcass equivalent.

\[ Q_{2t} = \frac{c_{2t}}{k_2} \left( N_t X_{2t} \right) = N_t \left( a_2 + b_2 t \right) \left( \frac{X_{2t}}{.56} \right), \text{ when } c_{2t} = a_2 + b_2 t \text{ and } k_2 = .56 \]

\[ Q_{3t} = \frac{c_{3t}}{k_3} \left( N_t X_{3t} - C_t - F_t \right) + \frac{c_{3t}'}{k_3} \left( F_t \right) \]

\[ = \frac{(a_3 + b_3 t)}{.70} \left[ N_t X_{3t} - \frac{3 Q_{5,t-1}}{a_5 + b_5 (t - 1)} r_{5,t-1} - F_t \right] + \frac{(a_3' + b_3't)}{k_3} F_t \]

\[ = \frac{(a_3 + b_3 t)}{.70} \left[ N_t X_{3t} - \frac{3 N_{t-1} X_{5,t-1}}{d + c (t - 1)} - F_t \right] + \frac{(a_3' + b_3't)}{k_3} F_t \]

when \( c_{3t} = a_3 + b_3 t \) is the feed conversion rate for broilers, \( c_{3t}' = a_3' + b_3't \) is the feed conversion rate for farm raised chickens, \( k_3 \) is the dressing percentage for chickens, \( C_t \) is the chicken base (assumed equal to the meat equivalent of the equilibrium demand number of hens for the previous year for projective analyses), and \( F_t \) is the retail equivalent amount of chicken meat from farm raised chickens. The number “3” is the assumed yield for hens, and \( r_{5t} = d + et \) is the average laying rate per hen per year in dozens of eggs.

\[ Q_{4t} = \frac{c_{4t}}{k_4} \left( N_t X_{4t} \right) \]

\[ = N_t \left( a_4 + b_4 t \right) \left( \frac{X_{4t}}{.77} \right), \text{ when } c_{4t} = a_4 + b_4 t \text{ and } k_4 = .77 \]

\[ Q_{5t} = \frac{c_{5t}}{k_5} \left( N_t X_{5t} \right) \]

\[ = N_t \left( a_5 + b_5 t \right) X_{5t}, \text{ when } c_{5t} = a_5 + b_5 t \text{ and } k_5 = 1.00 \]

\[ Q_{6t} = \frac{c_{6t}}{k_6} \left( N_t X_{6t} \right) \]

\[ = N_t \left( a_6 + b_6 t \right) X_{6t}, \text{ when } c_{6t} = a_6 + b_6 t \text{ and } k_6 = 1.00 \]

\[ Q_{7t} = \frac{c_{7t}}{k_7} \left( N_t X_{7t} \right) \]

\[ = N_t \left( a_7 + b_7 t \right) X_{7t}, \text{ when } c_{7t} = a_7 + b_7 t \text{ and } k_7 = 1.00 \]

\[ Q_t = Q_{ot} + \sum_{i=1}^{7} Q_{it}, \text{ is the aggregate demand function} \]

The basic demand functions for \( X_1, X_2, X_3, X_4, X_5, X_6, \) and \( X_7 \) are
used in the specific forms estimated earlier in this report. The marketing system price functions connecting \( P_1, P_2, \) and \( P_3, \) with \( P_1', P_2', \) and \( P_3' \) are also used as estimated. The productivity functions for \( P_1', P_2', \) and \( P_3' \) are altered as follows:

\[
P_1' = 0.87 (a_1 + b_1 t) P_1^* + 11.73
\]

\[
P_2' = (a_2 + b_2 t) P_2^* + 7.20
\]

\[
P_3' = (a_3 + b_3 t) P_3^* + 5.09 = 0.666 (a_3 + b_3 t) P_3^* + 3.494 (a_3 + b_3 t)
\]

\[
+ 5.09
\]

Finally, to provide full generality in the linear system, the trend relationships for \( N, X_9, X_{10}, X_8, \) and \( r_5 \) are written as,

\[
N_t = a_N (b_N)^t
\]

\[
X_{9t} = a_9 + b_9 t
\]

\[
X_{10t} = a_{10} + b_{10} t
\]

\[
X_{8t} = a_8 + b_8 t
\]

\[
r_{5t} = d + et
\]

After the substitution of all relevant functions in the basic demand system, the equilibrium requirement of \( P_1^* = P_2^* = P_3^* = P \) is imposed.

Without presenting the successive steps of substitution and simplification, the temporally based demand system is:

\[
Q_{ot} = K_t
\]

\[
Q_{1t} = a_N (b_N)^t (a_1 + b_1 t) [31.839980 - 6.401293 (a_{10} + b_{10} t) + 0.023320 (a_9 + b_9 t) + 0.023320 (a_9 + b_9 t)]
\]

\[
+ 171.980541 - 0.023961 (a_9 + b_9 t) - 0.295248 (a_1 + b_1 t) - 0.175440 (a_2 + b_2 t)\]

\[
+ 1.428571 [(a_3' - a_3) + (b_3' - b_3) t] T_t
\]

\[
Q_{2t} = a_N (b_N)^t (a_2 + b_2 t) [165.061645 - 7.347036 (a_{10} + b_{10} t) - 0.13509 (a_9 + b_9 t) - 2.502841 (a_2 + b_2 t) - 1.039478 (a_1 + b_1 t)]
\]

\[
Q_{3t} = a_N (b_N)^t (a_3 + b_3 t) [20.120322 - 2.142011 (a_3 + b_3 t) + 3.576829 (a_{10} + b_{10} t) + 0.007367 (a_9 + b_9 t)]
\]

\[
- 0.023961 (a_9 + b_9 t) - 0.295248 (a_1 + b_1 t) - 0.175440 (a_2 + b_2 t)\]

\[
+ 1.428571 [(a_3' - a_3) + (b_3' - b_3) t] T_t
\]

\[
Q_{4t} = a_N (b_N)^t (a_4 + b_4 t) [-2.062981 + 0.005278 (a_9 + b_9 t)]
\]

\[
Q_{5t} = a_N (b_N)^t (a_5 + b_5 t) [40.128793 - 0.005591 (a_9 + b_9 t)]
\]

\[
Q_{6t} = a_N (b_N)^t (a_6 + b_6 t) (350.000000)
\]

\[
Q_{7t} = a_N (b_N)^t (a_7 + b_7 t) [460.468773 - 13.346765 (a_8 + b_8 t)]
\]

\[
Q_t = K_t + \sum_{i=1}^{7} Q_{it}
\]

These demand functions provide us with a full picture of the time paths under the influence of the several possible trend factors. However, the incremental effects can be visualized more clearly if we compute the functions, \( \Delta Q_{ot} = Q_{t,t+1} - Q_{ot} \) showing the changes in demand for feed concentrates as we move from time point, \( t, \) to time
point \((t + 1)\). In a somewhat aggregated form these incremental functions are:

\[ \Delta Q_{it} = 0, \text{ when } K_t \text{ is assumed constant} \]

\[ \Delta Q_{1t} = (b_N - 1) Q_{1t} + b_N N_t \{(a_1 + b_1 t) \left[ -6.401293 b_{12} + .023320 b_9 
- (.957313 b_1 - .224075 b_2) P_t \right] + b_1 [31.839980 - 6.401293 (a_{10} + b_{10 t} + b_{10 t}) + .023320 (a_9 + b_9 + b_9 t) 
- (.957313 (a_1 + b_1 + b_1 t) - .224075 (a_2 + b_2 + b_2 t)) P_t] \} \]

\[ \Delta Q_{2t} = (b_N - 1) Q_{2t} + b_N N_t \{(a_2 + b_2 t) \left[ -7.347036 b_{10} - .013509 b_9 
- (2.502841 b_2 - 1.093478 b_1) P_t \right] + b_2 [165.061645 
- 7.347036 (a_{10} + b_{10} + b_{10 t}) - .013509 (a_9 + b_9 + b_9 t) 
- (2.502841 (a_2 + b_2 + b_2 t) - 1.093478 (a_1 + b_1 + b_1 t)) P_t] \} \]

\[ \Delta Q_{3t} = (b_N - 1) (Q_{3t} - f_t) + b_N N_t \left\{(a_3 + b_3 t) \left[ -2.142011 b_3 + 3.576829 b_{10} 
+ .007367 b_9 - (.408294 b_3 - .295248 b_1 - .175440 b_2) P_t 
+ \frac{.023961 b_9 d + e (171.980541 - .023961 a_9)}{b_N (d + et)} \right] + b_3 \left[ 20.120322 
- 2.142011 (a_3 + b_3 + b_3 t) + 3.576829 (a_{10} + b_{10} + b_{10 t}) 
+ .007367 (a_9 + b_9 + b_9 t) 
- (.408294 (a_3 + b_3 + b_3 t) - .295248 (a_1 + b_1 + b_1 t) 
- .175440 (a_2 + b_2 + b_2 t)) \right] \right\} + 1.428571 \left\{ \left[ (a_3' - a_3) + (b_3' - b_3) t \right] \Delta F_t 
+ (b_3' - b_3) (F_t + \Delta F_t) \right\} \]

where \( f_t = 1.428571 \left[ (a_3' - a_3) + (b_3' - b_3) t \right] F_t \)

\[ \Delta Q_{4t} = (b_N - 1) Q_{4t} + b_N N_t \{(a_4 + b_4 t) (.005278 b_9) + b_4 [-2.062981 
+ .005278 (a_9 + b_9 + b_9 t)] \}

\[ \Delta Q_{5t} = (b_N - 1) Q_{5t} + b_N N_t \{(a_5 + b_5 t) (-.005591 b_9) + b_5 [40.128793 
- .005591 (a_9 + b_9 + b_9 t)] \}

\[ \Delta Q_{6t} = (b_N - 1) Q_{6t} + b_N N_t \{b_6 \left( 350.000000 \right) \}

\[ \Delta Q_{7t} = (b_N - 1) Q_{7t} + b_N N_t \{(a_7 + b_7 t) (-13.346765 b_8) 
+ b_7 [460.468773 - 13.346765 (a_8 + b_8 + b_8 t)] \}

\[ \Delta Q_t = \sum_{i=1}^{7} \Delta Q_{it} \]

Excluding \( \Delta Q_{5t} \), the interpretation of these incremental functions is rather simple. Consider \( Q_{it} = N_t c_{it} X_{it} \) as illustrative of the separate demand functions, excluding the special case for broilers. With \( N_{t+1} = b_N N_t, c_{i, t+1} = c_{it} + b_1 \) and \( X_{i, t+1} = X_{it} + \Delta X_{it} \), we have the result
that $\Delta Q_{it} = (b_N - 1) Q_{it} + b_t N_{it}$ ($c_{it} \Delta X_{it'} + b_t [X_{it'} + \Delta X_{it'}]$). Verbally, this states that the total increment in feed concentrate demand in the $i$th use is equal to the rate of population increase times the old demand plus the product of the new population and the sum of the old conversion rate times the change in the per capita product demand and the change in the conversion rate times the new per capita product demand.

Let us consider $\Delta Q_{2t}$ in detail as illustrative of the general analytic content of these incremental functions. By setting $b_1$, $b_2$, $b_9$, and $b_{10}$ equal to zero, we secure the pure population effect. Under these conditions $\Delta Q_{2t} = (b_N - 1) Q_{2t}$, and as long as $b_N > 1$ we have a geometrically expanding demand. Although one could set $b_N = 1$ to study the effects of $b_1$, $b_2$, $b_9$ and $b_{10}$ independent of population change, this would not be very realistic. Consequently, consideration of the effects of $b_1$, $b_2$, $b_9$, and $b_{10}$ must admit a joint effect with population change.

Next let $b_1 = 0$ (logically negative) and $b_2$, $b_9$, and $b_{10} = 0$. Then $\Delta Q_{2t} = (b_N - 1) Q_{2t} + b_t N_{it} \{a_2 (1.039478 b_t) P_t\}$. With $b_N$ and $a_2$ positive and $b_1$ negative, we notice that the effect of $b_1$ is to make the second term negative. Whether $\Delta Q_{2t}$ is positive or negative depends on the relative size of the positive first term and the negative second term—the positive population effect may be greater than the negative conversion effect. These results are logical. With $b_1$ negative, the supply costs for beef would decline relative to pork and the substitution effect would depress the demand for pork and the derived demand for feed to be used in pork production. Also notice that the depressing effect would be larger at higher feed price levels.

Let $b_2 = 0$ (logically negative) and $b_1$, $b_9$ and $b_{10} = 0$. Then

$$\Delta Q_{2t} = (b_N - 1) Q_{2t} + b_t N_{it} \left\{ (a_2 + b_2 t) (-2.502841 b_2) P_t + b_2 \right\}$$

$$= \left[ 165.061645 - 7.347036 a_10 - .013509 a_9 \right] - \left\{ 2.502841 (a_2 + b_2 + b_2 t) - 1.039478 a_1 \right\} P_t \right\}$$

This result is slightly more complex, but the combined second term will be negative. Whether $\Delta Q_{2t}$ is positive or negative depends on the relative size of $(b_N - 1) Q_{2t}$ and the negative second term.

Let $b_9 = 0$ (logically positive) and $b_1$, $b_2$, and $b_{10} = 0$. Then $\Delta Q_{2t} = \left( b_N - 1 \right) Q_{2t} + b_t N_{it} \{a_2 (-0.013509 b_9)\}$. The second term is negative and the sign of $\Delta Q_{2t}$ is again dependent on the relative sizes of the two terms. Finally let $b_{10} = 0$ and $b_1$, $b_2$, $b_9 = 0$. Then $\Delta Q_{2t} = \left( b_N - 1 \right) Q_{2t} + b_t N_{it} \{a_2 (-7.347036 b_{10})\}$. With $b_{10} > 0$, this results in the same situation as resulted when $b_9$ was considered.

It should be observed that if $Q_{it} = A_t + B_t P_t$, that is, the demand is price dependent, then changing conversion rates ($b_t$, $b_j = 0$) affect both $A_t$ and $B_t$ if $b_i = 0$ and affect $B_t$ if a competitive $b_j = 0$. If the constant
terms of the productivity functions had been permitted to change under the influence of changing conversion rates, then both $A_t$ and $B_t$ would have been influenced in both cases. Because $X_9$ and $X_{10}$ entered the demand functions as shift variables, changes in either of them ($b_9$, $b_{10} \neq 0$) only affects the constant term $A_t$.

It is appropriate at this point to evaluate the functions $Q_{it}$ and $\Delta Q_{it}$ for conditions approximating those that occurred in the 1949-59 period. When projected into the 1960’s, the results should provide relevant features of future demand prospects in the livestock-feed sector. The following data are estimated values for the 1949-59 period.

$$
\begin{align*}
&\begin{array}{ll}
a_1 = 7.0 & \quad a_6 = a_7 = .33 \\
b_1 = 0 & \quad b_6 = b_7 = 0 \\
a_2 = 5.0 & \quad a_8 = 6.231823 \\
b_2 = 0 & \quad b_8 = .319090 \\
a_3 = 4.0 & \quad a_9 = 1,319.045420 \\
b_3 = -.05 & \quad b_9 = 58.190916 \\
a_3' = 6.0 & \quad a_{10} = 1.272555 \\
b_3' = -.05 & \quad b_{10} = .078364 \\
a_4 = 5.5 & \quad a_N = 149.1 \\
b_4 = 0 & \quad b_N = 1.0174 \\
a_5 = 7.8 \text{ (1949-57)} & \quad d = 14.196971 \\
b_5 = -.10 \text{ (1949-57)} & \quad e = .293939 \\
a_5' = 7.0 \text{ (1958-59)} & \quad t = 0 \text{ (1949)} \\
b_5' = 0 \text{ (1958-59)} & \\
\end{array}
\end{align*}
$$

The components $Q_{ot}$ and $F_t$ offer special difficulties. Only crude approximations will be used. For the 1949-59 period, $Q_{ot} = 60,000$ million pounds will be employed. A value of $(50,000 + 1000t)$ will be employed for 1960-70 (i.e. $t = 11, \ldots , 21$). During the period 1949-59, $F_t$, as estimated, ranged from 840 million pounds to about 140 million pounds with a progressive decline. $F_t = 840 - 70t$ will be used for this period, and $F_t = 140$ will be used for future projections.

Upon substitution of these values into the functions $Q_{it}$ and $\Delta Q_{it}$, we secure for the 1949-59 period.

$$
\begin{align*}
Q_{ot} &= 60,000 \\
\Delta Q_{ot} &= 0 \\
Q_{1t} &= (1.0174)^t \left(56,833.217310 + 892.736728t - 5,824.700164 P_t\right) \\
\Delta Q_{1t} &= .0174 Q_{1t} + 892.736728 (1.0174)^{t-1} \\
&\quad = (1.0174)^t \left(1,897.168330 + 15.533619 t - 101.349783 P_t\right) \\
Q_{2t} &= (1.0174)^t \left(102,799.345562 - 1,015.254702 t - 3,904.817921 P_t\right) \\
\Delta Q_{2t} &= .0174 Q_{2t} - 1,015.254702 (1.0174)^{t-1} \\
&\quad = (1.0174)^t \left(755.788482 - 17.665432 t - 67.943832 P_t\right) \\
Q_{3t} &= (1.0174)^t \left(596.4 - 7.455 t\right) \left[25.821397 + .816088 t - \frac{141.769206 - 1.394313 t}{14.144945 + .299054 t} + (1.310760 + .020415 t) P_t\right] + (2,400 - 200 t)
\end{align*}
$$
\[ \Delta Q_{st} = (1.0174)^t \left\{ (599.192643 - 7.584717 t) \left[ .816088 + \frac{61.05667}{(14.144945 + .299054 t)(14.196971 + .293939 t)} + .020415 P_t \right] + (2.792643 - .129717 t) \left[ 25.821397 + 816088 t \right] \right\} - 200 \]

\[ Q_{4t} = (1.0174)^t (4,017.376567 + 251.863597 t) \]
\[ \Delta Q_{4t} = .0174 Q_{4t} + 251.863319 (1.0174)^{t+1} \]
\[ Q_{5t} = (1.0174)^t (1162.98 - 14.91 t) (32.754010 - .325345 t) \text{ for } (1949-57) \]
\[ \Delta Q_{5t} = .0174 Q_{5t} + (1.0174)^{t+1} (-381.612595 + 4.883428 t) \]
\[ = (1.0174)^t [(20.235852 - .259743 t) (32.754010 - .325345 t) - (388.252654 - 4.968400 t)] \text{ for } (1949-57) \]
\[ \Delta Q_{5t} = .0174 Q_{5t} - 339.563006 (1.0174)^{t+1} \]
\[ = (1.0174)^t (249.353862 - 5.908396 t) \text{ for } (1958-) \]
\[ Q_{6t} = (1.0174)^t (17,210.50) \]
\[ \Delta Q_{6t} = (1.0174)^t (299.462700) \]
\[ Q_{7t} = (1.0174)^t (18,564.001405 - 209.564671 t) \]
\[ \Delta Q_{7t} = .0174 Q_{7t} - 209.546671 (1.0174)^{t+1} \]
\[ = (1.0174)^t (109.820812 - 3.646112 t) \]
\[ Q_t = Q_{ot} + \sum_{i=1}^{7} Q_{it} \]
\[ \Delta Q_t = \sum_{i=1}^{7} \Delta Q_{it} \]

These functions have been used to compute the information found in Table 6 for the years 1949 through 1959. The results are more easily interpreted after two demand projections for 1960 through 1970 have been developed.

The first projection (Projection I) will be conservative on efficiency gains and consequently optimistic on feed concentrate demand levels. Basically, all rates will be frozen at 1959 levels. Only population, income, and marketing cost trends will be assumed to continue. Assumptions for Projection I are as follows for the 1960-70 period:

\[
\begin{align*}
a_1 &= 7.0 \\
b_1 &= 0 \\
a_2 &= 5.0 \\
b_2 &= 0 \\
a_3 &= 3.5 \\
b_3 &= 0 \\
a_4 &= 9.5 \\
b_4 &= 0 \\
a_5 &= 1,319.045420 \\
b_5 &= 58.190916 \\
a_6 &= 1.272555
\end{align*}
\]

43
\[
\begin{align*}
b_3 &= 0 & b_{10} &= 0.078364 \\
a_3' &= 5.5 & a_N &= 149.1 \\
b_3' &= 0 & b_N &= 1.0174 \\
a_4 &= 5.5 & d &= 17 \\
b_4 &= 0 & e &= 0 \\
a_5 &= 7.0 & t &= 0 \ (1949) \\
b_5 &= 0 & F_t &= 140 \\
a_6 = a_7 &= .33 & Q_{it} &= 50,000 + 1,000 \ t \ for \ t = 11 \ through \ 21 \\
b_6 = b_7 &= 0
\end{align*}
\]

The effect of these changes will be to alter the trends in \(Q_0, Q_3, Q_7\) and \(Q\) from their paths for the 1949-59 period. We will not repeat the writing of the individual demand functions, but will present the Projection I results for 1960 through 1970 in Table 7.

The second projection (Projection II) is a low level outlook. It differs only slightly from the 1949-59 basis. The differences are (1) conversion rates for beef finishing drop linearly from 7.0 pounds to 6.5 pounds per pound of gain between 1960 and 1970; (2) a similar drop in the rate for hogs from 5.0 to 4.5 pounds per pound of gain is assumed; (3) the conversion rate for turkeys will drop from 5.5 to 5.0 pounds; (4) feed conversion to eggs will remain constant at 7.0 pounds per dozen; (5) the farm-raised chicken base (excluding hens)

![Graph showing U.S. Population and Feed Concentrate Demand Trends, 1949-70 (Demand based on a price of $2.00 per hundredweight of corn equivalent)](image)

Figure 1. U. S. Population and Feed Concentrate Demand Trends, 1949-70 (Demand based on a price of $2.00 per hundredweight of corn equivalent)
will remain constant at 140 million pounds; (6) the other uses com-
ponent will rise 1,000 million pounds per year from 61,000 to 71,000
million pounds between 1960 and 1970, and (7) margarine consump-
tion will be constant at 9.5 pounds per capita. The effects of these
changes are given in Table 8.

Figure 1 has been drawn to provide a visual aid for the interpreta-
tion of the estimates given in Tables 6, 7, and 8.

The reader should study Tables 6, 7, and 8 and Figure 1 in detail.
In general, the following observations are relevant:

1. Demand for feed concentrates for beef finishing rises at an in-
creasing rate and more rapidly than population. Per capita
annual rates increase from 303 pounds in 1949 to 429 pounds
(I) or 403 pounds (II) in 1970. The price elasticity decreases from
-.26 to -.18 (I) or -.17 (II) at a feed grain price of 2.00 cents
per pound, between 1949 and 1970.

2. Demand for feed concentrates for pork production rises at a
decreasing rate and much slower than population for 1949-59
and 1960-70 under projection I. Per capita annual rates decrease
from 637 pounds in 1949 to 494 pounds (I) in 1970. The price
elasticity increases from about -.08 to -.11 (I) during this period,
at a price level of 2.00 cents per pound. Under projection II an
absolute decline in total demand would occur. Per capita de-
mand would drop to 452 pounds in 1970 and the price elasticity
would rise to -.09 at a price level of 2.00 cents per pound.

3. Demand for feed concentrates for broiler production rises at a
rate slightly faster than population from 1949-59 and 1959-70
under projection II (a change in the per capita rate from 90 to
106 pounds and 106 to 121 pounds) and even more rapidly from
1959-1970 under projection I (a change in the per capita rate
from 106 to 136 pounds). These demand rates may be slightly
high for the projected period because the positive influence of
X_{10} may reverse. This factor would also affect the indicated
positive price elasticity somewhat. The computed price elasticity
changes from .12 in 1949 to .08 (I) or .07 (II) in 1970 at a price
level of 2.00 cents per pound.

4. Demand for turkey utilization of feed concentrates rises rapidly
and faster than population. Per capita rates increase from 27
pounds in 1949 to 62 pounds (I) or 57 pounds (II) in 1970.

5. Demand for feed concentrates in egg production decreases in
absolute amount between 1949 and 1957 and rises at a slightly
decreasing rate from 1957-70. The latter rate of increase is insig-
nificant. For practical purposes this demand category is nearly
constant.

6. Demand for feed concentrates in fluid milk production rises at
the same rate as population because of the basic constant per
capita demand assumption.
<table>
<thead>
<tr>
<th>Demand Category</th>
<th>1949</th>
<th>1950</th>
<th>1951</th>
<th>1952</th>
<th>1953</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{1t} )</td>
<td>Constant Term</td>
<td>56,833.21</td>
<td>58,730.39</td>
<td>60,676.38</td>
<td>62,672.32</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>-5,824.70</td>
<td>-5,926.04</td>
<td>-6,029.16</td>
<td>-6,134.08</td>
</tr>
<tr>
<td></td>
<td>When ( P = 2.00 )</td>
<td>45,184</td>
<td>46,878</td>
<td>48,618</td>
<td>50,404</td>
</tr>
</tbody>
</table>

| \( Q_{2t} \)  | Constant Term | 102,799.35 | 103,555.13 | 104,306.12 | 105,051.89 | 105,792.00 |
|                | Price Coefficient | -3,904.82 | -3,972.76 | -4,041.89 | -4,112.22 | -4,183.77 |
|                | When \( P = 2.00 \) | 94,990 | 95,610 | 96,222 | 96,827 | 97,424 |

| \( Q_{3t} \)  | Constant Term | 11,822.40 | 12,337.69 | 12,850.32 | 13,360.27 | 13,867.49 |
|                | Price Coefficient | 781.74 | 797.63 | 813.52 | 829.41 | 845.28 |
|                | When \( P = 2.00 \) | 13,386 | 13,933 | 14,477 | 15,019 | 15,558 |

\( Q_t \)

| \( Q_{4t} \)  | 4,017.4 | 4,343.5 | 4,679.8 | 5,026.5 | 5,383.8 |
| \( Q_{5t} \)  | 38,092.3 | 37,878.2 | 37,655.2 | 37,423.2 | 37,182.1 |
| \( Q_{6t} \)  | 17,210.5 | 17,510.0 | 17,814.6 | 18,124.6 | 18,440.0 |

\( Q_{7t} \)

| \( Q_{8t} \)  | 18,564.0 | 18,678.8 | 18,781.8 | 18,888.0 | 18,992.1 |
| \( Q_{9t} \)  | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |

\( Q_{t} \)

| \( \text{Constant Term} \) | 309,339.16 | 318,128.71 | 316,764.22 | 320,546.78 | 324,376.80 |
| \( \text{Price Coefficient} \) | -8,947.78 | -9,101.17 | -9,257.53 | -9,416.89 | -9,579.29 |
| \( \text{When } P = 2.00 \) | 291,444 | 294,926 | 298,249 | 301,713 | 305,218 |

* For \( Q_{1t} \), \( Q_{2t} \), \( Q_{3t} \), and \( Q_{4t} \), the demand functions are \( Q_{1t} = A_{1t} - B_{1t}P_t \).
* The rows labeled "Constant Term" give the \( A_{1t} \) values.
* The rows labeled "Price Coefficient" give the \( -B_{1t} \) values.
* The rows labeled "When \( P = 2 \)" are the values of \( Q_{1t} = A_{1t} - 2B_{1t} \) or the demand at a price level of 2.00 cents per pound of corn equivalent.
(Table 6, Continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>66,818.59</td>
<td>68,971.30</td>
<td>71,178.68</td>
<td>73,442.09</td>
<td>75,762.66</td>
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<tr>
<td></td>
<td>Price Coefficient</td>
<td>-6,349.39</td>
<td>-6,459.88</td>
<td>-6,572.27</td>
<td>-6,686.63</td>
<td>-6,802.98</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>54,120</td>
<td>56,052</td>
<td>58,034</td>
<td>60,069</td>
<td>62,157</td>
</tr>
<tr>
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<td>Constant Term</td>
<td>106,526.06</td>
<td>107,253.61</td>
<td>107,974.22</td>
<td>108,687.56</td>
<td>109,392.97</td>
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<tr>
<td></td>
<td>Price Coefficient</td>
<td>-4,256.57</td>
<td>-4,330.63</td>
<td>-4,405.98</td>
<td>-4,482.65</td>
<td>-4,560.65</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>98,013</td>
<td>98,592</td>
<td>99,162</td>
<td>99,722</td>
<td>100,272</td>
</tr>
<tr>
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<td>Constant Term</td>
<td>14,371.92</td>
<td>14,873.42</td>
<td>15,371.85</td>
<td>15,867.03</td>
<td>16,358.72</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>861.11</td>
<td>876.90</td>
<td>892.64</td>
<td>908.31</td>
<td>923.90</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>16,094</td>
<td>16,627</td>
<td>17,157</td>
<td>17,684</td>
<td>18,207</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>5,752.0</td>
<td>6,131.4</td>
<td>6,522.3</td>
<td>6,924.9</td>
<td>7,339.6</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>36,931.8</td>
<td>36,672.3</td>
<td>36,403.6</td>
<td>36,125.6</td>
<td>36,357.6</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>18,760.8</td>
<td>19,087.3</td>
<td>19,419.4</td>
<td>19,757.3</td>
<td>20,101.1</td>
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<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>19,094.2</td>
<td>19,194.0</td>
<td>19,291.5</td>
<td>19,386.6</td>
<td>19,479.2</td>
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<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>328,255.37</td>
<td>332,183.33</td>
<td>336,161.55</td>
<td>340,191.08</td>
<td>344,791.85</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>-9,744.85</td>
<td>-9,913.61</td>
<td>-10,085.61</td>
<td>-10,260.97</td>
<td>-10,439.73</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>308,766</td>
<td>312,356</td>
<td>315,990</td>
<td>319,669</td>
<td>323,912</td>
</tr>
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</table>
Table 7. Estimated Feed Concentrate Demand Trends for 1960-70 in U. S., Projection I (Millions of Pounds)

<table>
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<tbody>
<tr>
<td>$Q_{it}$</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>80,580.67</td>
<td>83,080.84</td>
<td>85,643.63</td>
<td>88,270.40</td>
<td>90,962.69</td>
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<tr>
<td>Price Coefficient</td>
<td>-7,041.78</td>
<td>-7,164.31</td>
<td>-7,288.97</td>
<td>-7,415.80</td>
<td>-7,544.83</td>
</tr>
<tr>
<td>When $P = 2.00$</td>
<td>66,497</td>
<td>68,752</td>
<td>71,066</td>
<td>73,439</td>
<td>75,873</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>110,778.14</td>
<td>111,456.95</td>
<td>112,125.84</td>
<td>112,784.23</td>
<td>113,431.59</td>
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<tr>
<td>Price Coefficient</td>
<td>-4,720.74</td>
<td>-4,802.88</td>
<td>-4,886.45</td>
<td>-4,971.47</td>
<td>-5,057.98</td>
</tr>
<tr>
<td>When $P = 2.00$</td>
<td>101,337</td>
<td>101,851</td>
<td>102,353</td>
<td>102,841</td>
<td>103,316</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>17,674.63</td>
<td>18,482.03</td>
<td>19,312.30</td>
<td>20,165.99</td>
<td>21,043.66</td>
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<tr>
<td>Price Coefficient</td>
<td>955.74</td>
<td>972.37</td>
<td>989.29</td>
<td>1,006.51</td>
<td>1,024.02</td>
</tr>
<tr>
<td>When $P = 2.00$</td>
<td>19,586</td>
<td>20,427</td>
<td>21,291</td>
<td>22,179</td>
<td>23,092</td>
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<tr>
<td>$Q_{it}$</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>8,206.2</td>
<td>8,658.8</td>
<td>9,124.6</td>
<td>9,604.1</td>
<td>10,097.4</td>
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<tr>
<td>$Q_{it}$</td>
<td>36,812.8</td>
<td>37,035.7</td>
<td>37,255.2</td>
<td>37,471.1</td>
<td>37,683.3</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>20,806.7</td>
<td>21,168.7</td>
<td>21,537.0</td>
<td>21,911.8</td>
<td>22,293.1</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>19,848.3</td>
<td>20,193.7</td>
<td>20,545.1</td>
<td>20,902.5</td>
<td>21,266.2</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td>61,000</td>
<td>62,000</td>
<td>63,000</td>
<td>64,000</td>
<td>65,000</td>
</tr>
<tr>
<td>$Q_{it}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>355,707.44</td>
<td>362,076.72</td>
<td>368,543.67</td>
<td>375,110.12</td>
<td>381,777.94</td>
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<td>Price Coefficient</td>
<td>-10,806.78</td>
<td>-10,994.72</td>
<td>-11,168.13</td>
<td>-11,380.76</td>
<td>-11,578.79</td>
</tr>
<tr>
<td>When $P = 2.00$</td>
<td>334,094</td>
<td>340,087</td>
<td>346,207</td>
<td>352,349</td>
<td>358,620</td>
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</table>

For $Q_{it}$, $Q_{it}$, $Q_{it}$, and $Q_{it}$, the demand functions are $Q_{it} = A_{it} - B_{it}P_t$.
The rows labeled "Constant Term" give the $A_{it}$ values
The rows labeled "Price Coefficient" give the $-B_{it}$ values
The rows labeled "When $P = 2$" are the values of $Q_{it} = A_{it} - 2B_{it}$ or the demand at a price level of 2.00 cents per pound of corn equivalent.
(Table 7, Continued)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{it} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>93,721.90</td>
<td>96,549.65</td>
<td>99,447.43</td>
<td>102,416.76</td>
<td>105,459.38</td>
<td>108,576.80</td>
</tr>
<tr>
<td>Price Coefficient</td>
<td>-7,676.11</td>
<td>-7,809.67</td>
<td>-7,945.57</td>
<td>-8,083.81</td>
<td>-8,224.48</td>
<td>-8,367.58</td>
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<tr>
<td>When ( P = 2.00 )</td>
<td>78.370</td>
<td>80,930</td>
<td>83,556</td>
<td>86,249</td>
<td>89,010</td>
<td>91,842</td>
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<tr>
<td>( Q_{st} )</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Constant Term</td>
<td>114,067.30</td>
<td>114,690.86</td>
<td>115,301.58</td>
<td>115,898.75</td>
<td>116,481.88</td>
<td>117,050.12</td>
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<tr>
<td>Price Coefficient</td>
<td>-5,145.98</td>
<td>-5,235.53</td>
<td>-5,326.62</td>
<td>-5,419.31</td>
<td>-5,513.60</td>
<td>-5,609.54</td>
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<tr>
<td>When ( P = 2.00 )</td>
<td>103,775</td>
<td>104,220</td>
<td>104,648</td>
<td>105,060</td>
<td>105,455</td>
<td>105,831</td>
</tr>
<tr>
<td>( Q_{st} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>21,945.87</td>
<td>22,873.26</td>
<td>23,826.38</td>
<td>24,805.86</td>
<td>25,812.35</td>
<td>26,846.46</td>
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<tr>
<td>Price Coefficient</td>
<td>1,041.84</td>
<td>1,059.96</td>
<td>1,078.41</td>
<td>1,097.17</td>
<td>1,116.26</td>
<td>1,135.68</td>
</tr>
<tr>
<td>When ( P = 2.00 )</td>
<td>24,030</td>
<td>24,993</td>
<td>25,983</td>
<td>27,000</td>
<td>28,045</td>
<td>29,118</td>
</tr>
<tr>
<td>( Q_{st} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>10,605.0</td>
<td>11,127.3</td>
<td>11,664.4</td>
<td>12,217.0</td>
<td>12,785.2</td>
<td>13,369.4</td>
</tr>
<tr>
<td>Price Coefficient</td>
<td>37,891.4</td>
<td>38,095.5</td>
<td>38,295.1</td>
<td>38,490.2</td>
<td>38,680.5</td>
<td>38,865.7</td>
</tr>
<tr>
<td>When ( P = 2.00 )</td>
<td>22,680.9</td>
<td>23,075.6</td>
<td>23,477.1</td>
<td>23,885.6</td>
<td>24,301.2</td>
<td>24,724.1</td>
</tr>
<tr>
<td>( Q_{st} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>21,636.3</td>
<td>22,012.7</td>
<td>22,395.8</td>
<td>22,785.4</td>
<td>23,181.9</td>
<td>23,585.3</td>
</tr>
<tr>
<td>Price Coefficient</td>
<td>66,000</td>
<td>67,000</td>
<td>68,000</td>
<td>69,000</td>
<td>70,000</td>
<td>71,000</td>
</tr>
<tr>
<td>When ( P = 2.00 )</td>
<td>388,548.67</td>
<td>395,424.87</td>
<td>402,407.78</td>
<td>409,499.57</td>
<td>416,702.41</td>
<td>424,017.88</td>
</tr>
<tr>
<td>( Q_{st} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>-11,780.25</td>
<td>-11,985.24</td>
<td>-12,193.78</td>
<td>-12,405.95</td>
<td>-12,621.82</td>
<td>-12,841.44</td>
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<tr>
<td>Price Coefficient</td>
<td>364,988</td>
<td>371,454</td>
<td>378,020</td>
<td>384,688</td>
<td>391,459</td>
<td>398,335</td>
</tr>
</tbody>
</table>

\( Q_{it} \): where \( i \) represents the demand category.
Table 8. Estimated Feed Concentrate Demand Trends for 1960-70 in U.S., Projection II (Millions of Pounds)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Q_{at}^*</td>
<td>Constant Term</td>
<td>80,580.67</td>
<td>82,487.41</td>
<td>84,420.14</td>
<td>86,378.90</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>-7,041.78</td>
<td>-7,066.40</td>
<td>-7,090.44</td>
<td>-7,113.86</td>
</tr>
<tr>
<td></td>
<td>When P = 2.00</td>
<td>66,479</td>
<td>68,355</td>
<td>70,239</td>
<td>72,151</td>
</tr>
<tr>
<td>Q_{at}^*</td>
<td>Constant Term</td>
<td>110,778.14</td>
<td>110,342.38</td>
<td>109,883.32</td>
<td>109,400.70</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>-4,720.75</td>
<td>-4,688.44</td>
<td>-4,654.94</td>
<td>-4,620.25</td>
</tr>
<tr>
<td></td>
<td>When P = 2.00</td>
<td>101,337</td>
<td>100,965</td>
<td>100,573</td>
<td>100,160</td>
</tr>
<tr>
<td>Q_{at}^*</td>
<td>Constant Term</td>
<td>17,530.63</td>
<td>18,210.25</td>
<td>18,885.19</td>
<td>19,555.16</td>
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<tr>
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<td>Price Coefficient</td>
<td>954.79</td>
<td>955.38</td>
<td>955.76</td>
<td>955.92</td>
</tr>
<tr>
<td></td>
<td>When P = 2.00</td>
<td>19,440</td>
<td>20,121</td>
<td>20,797</td>
<td>21,467</td>
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<tr>
<td>Q_{at}</td>
<td>8,206.2</td>
<td>8,580.1</td>
<td>8,958.7</td>
<td>9,342.1</td>
<td>9,730.2</td>
</tr>
<tr>
<td>Q_{bt}</td>
<td>36,812.8</td>
<td>37,035.7</td>
<td>37,255.2</td>
<td>37,471.1</td>
<td>37,683.3</td>
</tr>
<tr>
<td>Q_{bt}</td>
<td>20,806.7</td>
<td>21,168.7</td>
<td>21,537.0</td>
<td>21,911.8</td>
<td>22,293.1</td>
</tr>
<tr>
<td>Q_{bt}</td>
<td>19,848.3</td>
<td>20,193.7</td>
<td>20,545.1</td>
<td>20,902.5</td>
<td>21,266.2</td>
</tr>
<tr>
<td>Q_{bt}</td>
<td>61,000</td>
<td>62,000</td>
<td>63,000</td>
<td>64,000</td>
<td>65,000</td>
</tr>
<tr>
<td>Q_{bt}^*</td>
<td>Constant Term</td>
<td>355,563.44</td>
<td>360,018.24</td>
<td>364,484.65</td>
<td>368,962.18</td>
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<tr>
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<td>Price Coefficient</td>
<td>-10,807.74</td>
<td>-10,799.46</td>
<td>-10,789.62</td>
<td>-10,778.19</td>
</tr>
<tr>
<td></td>
<td>When P = 2.00</td>
<td>333,948</td>
<td>338,419</td>
<td>342,905</td>
<td>347,406</td>
</tr>
</tbody>
</table>

*For Q_{at}, Q_{bt}, Q_{at}, and Q_{bt}, the demand functions are Q_{at} = A_{at} - B_{at}P_{t}.
The rows labeled “Constant Term” give the A_{at} values.
The rows labeled “Price Coefficient” give the -B_{at} values.
The rows labeled “When P = 2” are the values of Q_{at} = A_{at} - 2B_{at} or the demand at a price level of 2.00 cents per pound of corn equivalent.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>90,374.69</td>
<td>92,411.81</td>
<td>94,475.06</td>
<td>96,564.37</td>
<td>98,679.85</td>
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<td>Price Coefficient</td>
<td>-7,158.83</td>
<td>-7,180.33</td>
<td>-7,201.16</td>
<td>-7,221.31</td>
<td>-7,240.75</td>
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<td>When $P = 2.00$</td>
<td>76,057</td>
<td>78,051</td>
<td>80,073</td>
<td>82,122</td>
<td>84,198</td>
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<tr>
<td>$Q_{et}$</td>
<td>Constant Term</td>
<td>108,363.94</td>
<td>107,809.40</td>
<td>107,230.47</td>
<td>106,626.85</td>
<td>105,998.51</td>
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<tr>
<td></td>
<td>Price Coefficient</td>
<td>-4,547.24</td>
<td>-4,508.92</td>
<td>-4,469.37</td>
<td>-4,428.60</td>
<td>-4,386.59</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>99,269</td>
<td>98,792</td>
<td>98,292</td>
<td>97,770</td>
<td>97,225</td>
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<tr>
<td>$Q_{it}$</td>
<td>Constant Term</td>
<td>20,878.02</td>
<td>21,530.17</td>
<td>22,175.46</td>
<td>22,813.34</td>
<td>23,443.26</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>955.57</td>
<td>955.04</td>
<td>954.27</td>
<td>953.25</td>
<td>951.97</td>
</tr>
<tr>
<td></td>
<td>When $P = 2.00$</td>
<td>22,789</td>
<td>23,440</td>
<td>24,084</td>
<td>24,720</td>
<td>24,347</td>
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<tr>
<td>$Q_{et}$</td>
<td>Constant Term</td>
<td>10,123.0</td>
<td>10,520.3</td>
<td>10,922.2</td>
<td>11,328.4</td>
<td>11,739.1</td>
</tr>
<tr>
<td>$Q_{et}$</td>
<td>37,891.4</td>
<td>38,095.5</td>
<td>38,295.1</td>
<td>38,490.2</td>
<td>38,680.5</td>
<td>38,865.7</td>
</tr>
<tr>
<td>$Q_{et}$</td>
<td>22,680.9</td>
<td>23,075.6</td>
<td>23,477.1</td>
<td>23,885.6</td>
<td>24,301.2</td>
<td>24,724.1</td>
</tr>
<tr>
<td>$Q_{et}$</td>
<td>21,636.3</td>
<td>22,012.7</td>
<td>22,395.8</td>
<td>22,785.4</td>
<td>23,181.9</td>
<td>23,585.3</td>
</tr>
<tr>
<td>$Q_{et}$</td>
<td>66,000</td>
<td>67,000</td>
<td>68,000</td>
<td>69,000</td>
<td>70,000</td>
<td>71,000</td>
</tr>
<tr>
<td>$Q_{et}$</td>
<td>Constant Term</td>
<td>377,948.25</td>
<td>382,455.48</td>
<td>386,971.19</td>
<td>391,494.16</td>
<td>396,024.32</td>
</tr>
<tr>
<td></td>
<td>Price Coefficient</td>
<td>-10,750.50</td>
<td>-10,734.21</td>
<td>-10,716.26</td>
<td>-10,696.66</td>
<td>-10,675.37</td>
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<td>When $P = 2.00$</td>
<td>356,447</td>
<td>360,987</td>
<td>365,539</td>
<td>370,101</td>
<td>374,674</td>
</tr>
</tbody>
</table>
7. Because of the trend in margarine consumption, demand for feed concentrates to produce manufacturing milk increases less rapidly than population from 1949-59 and at the same rate as population from 1960-70 when a constant margarine consumption rate was assumed.

8. Q_o, the demand in other uses, is constant for 1949-59 and rises 1,000 million pounds per year from 1960 to 1970, as assumed.

9. Total feed concentrate demand increases at a decreasing rate from 1949-59, at a slightly increasing rate under projection I and a decreasing rate under projection II for the period 1960-70. The per capita rates change from 1,953 pounds in 1949 to 1,851 pounds in 1959 to 1,861 pounds (I) or 1,773 pounds (II) in 1970. The price elasticity changes from -.061 in 1949 to -.064 (I) or -.056 (II) in 1970—practically no change—at a price level of 2.00 cents per pound.

10. The trends for 1960-70 are significantly different under the two projections. The aggregate effects would amount to about 19,000 million pounds difference in the annual rate of demand by 1970.

NATIONAL AGRICULTURAL POLICY CONSIDERATIONS

The previous section developed an estimate of the temporal path for the long-run derived demand for feed concentrates at the farm level for the 1949-59 calendar year period and two projections for 1960-70. In terms of economic progress, projection I assumed no improvements in conversion rates, while projection II was based on increasing efficiency in conversion rates. Aside from several other long-run conditions, it should be remembered that these analyses assumed an equilibrium growth rate for range beef operations and dairy herd culling that continuously contributed 70 percent of the beef supply demanded.

This section will relate the derived demand for feed concentrates to the further derived demand for land use in feed grain production. On the basis of estimated long-run feed concentrate demand and yield productivity trends per planted acre for feed grains, we will compute the estimates of land requirements for 1948-58 crop years and two projections for 1959-69 crop years. We will appraise the performance that these estimated acreages for the 1948-58 crop year period would have produced in meeting demand and the magnitudes for a consistent "weather stabilization" pool counterpart. The latter analysis will be considered under the situation such that the estimated trend demands from which the acreages were developed would be the effective levels of demand.

Using data for crop years 1937 through 1959, the estimated linear time trend equation for feed grain yield per planted acre in pounds
is $W = 1589.566 + 32.49t$, $(r = .873)$ when $t = 0$ for the 1948 crop year. This indicates that a linear time trend "explains" about 76 percent of the variation in yields per planted acre since 1937 and that about 24 percent of the variation might be attributed primarily to weather. The aggregate trend effect per year (32.49 pounds per planted acre) is the aggregate effect of wider use of fertilizers, more irrigation, improved varieties and their acceptance rate, changes in acreage composition for feed grains, and improved field practices. We will assume a continuation of this trend function for 1960-70. It assumes no reversal of the application of intensive practices in feed grain production. Some extensive aggregate shifts in land use may take place, but acreage in feed grains will be assumed to continue to be handled most economically under intensive practices.

We shall assume that the quantity of "other grains and by-products" supplied and used is fixed at 18 percent of total feed concentrate demand for all periods. All analyses will hold the price level at $2.00 per hundredweight of corn equivalent.\(^8\) It will be assumed that increased efficiencies of grain production will offset higher input prices and provide an equitable rise in real income to farmers at that price level for output. If competitive bidding for land use is reduced (by provision of collateral programs to increase human mobility), part of the excessive capitalization into land values could be transferred to the remaining operators for their labor and management. Rental arrangements would shift to reflect this fact and land investment values for owner-operators would be reduced.

The net demand for feed grains is estimated at 82 percent of total feed concentrate demand. Division of these estimated feed grain demands by the estimated values for yields per planted acre result in estimates of the expected acreage of land, having average productivity, required to meet demand over time. These values are given in Table 9.

Next, let us consider how well the computed equilibrium acreage for 1948-58 crop years would have produced supplies to meet estimated demand requirements for feed grains. Table 10 indicates that a maximum deficit of 48,152 million pounds would have occurred for the crop year 1957. The extremely low initial carryover from the 1947 crop year of 15,600 million pounds would have had to be increased to nearly 66,000 million pounds to avoid deficits later at a stable price level of $2.00 per hundredweight. This would have produced a maximum level

\(^8\) The reader has undoubtedly wondered whether actual weights or "corn equivalent" weights are being used. Actual weights of feed concentrates are being used as a good approximation to "corn equivalent" weights in a productivity sense. This avoids the weighted conversion problem and is reasonable since the overages for supplements would about offset the lesser productivity ratios for oats and barley. In general, supplements and feed grains are near complements in an efficient ration and gross substitutes between supplemented and non-supplemented rations.
Table 9. Estimated Acreage of Average Productivity Land Required to Produce Feed Grains to Equal Estimated Demand

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Millions of Acres</th>
<th>Crop Year</th>
<th>Millions of Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Estimated</td>
<td>Project I</td>
</tr>
<tr>
<td>1948</td>
<td>149.7</td>
<td>150.3</td>
<td>140.7</td>
</tr>
<tr>
<td>1949</td>
<td>147.6</td>
<td>149.1</td>
<td>140.9</td>
</tr>
<tr>
<td>1950</td>
<td>151.3</td>
<td>147.8</td>
<td>141.1</td>
</tr>
<tr>
<td>1951</td>
<td>143.6</td>
<td>146.7</td>
<td>141.3</td>
</tr>
<tr>
<td>1952</td>
<td>139.1</td>
<td>145.6</td>
<td>141.6</td>
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<tr>
<td>1953</td>
<td>140.7</td>
<td>144.5</td>
<td>141.9</td>
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<td>1954</td>
<td>155.5</td>
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<td>142.2</td>
</tr>
<tr>
<td>1955</td>
<td>157.8</td>
<td>142.6</td>
<td>142.6</td>
</tr>
<tr>
<td>1956</td>
<td>147.1</td>
<td>141.7</td>
<td>142.9</td>
</tr>
<tr>
<td>1957</td>
<td>152.6</td>
<td>141.1</td>
<td>143.3</td>
</tr>
<tr>
<td>1958</td>
<td>146.1</td>
<td>140.4</td>
<td>143.8</td>
</tr>
</tbody>
</table>

* Based on $2.00 per hundredweight of corn equivalent.

carryover of nearly 99,000 million pounds (49.5 million tons) from the 1949 crop year. With the weather variability exhibited from 1948 through 1958 crop years, this gives some idea of the maximum size of inventories that a “stabilizing” or “ever-normal-granary” operation might expect. Consequently, if our current base acreage were near 140 million acres, the carryover of 75.0 million tons into the 1960 crop year after several good weather years might be interpreted as being about 20-25 million tons in real surplus.

One might remark at this point that the most effective and economical location for the “stabilization” stocks would be in the western part of the feed grain producing area of the Midwest. This would coincide with the area of high yield variability, the area of comparative advantage for beef and pork conversion processes for feed grains, and

Table 10. Estimated Performance of Estimated Equilibrium Acreage in Meeting Feed Grain Demand, 1948-58 Crop Years

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Estimated Equilibrium Acreage (Million Acres)</th>
<th>Actual Yield Per Acre (Pounds)</th>
<th>Estimated Feed Grain Production (Million Pounds)</th>
<th>Carryover or Deficit (Million Pounds)</th>
<th>Total Supply (Million Pounds)</th>
<th>Estimated Demand (Million Pounds)</th>
<th>Carryout or Deficit (Million Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>150.3</td>
<td>1,809</td>
<td>271,893</td>
<td>15,600</td>
<td>287,493</td>
<td>238,984</td>
<td>48,509</td>
</tr>
<tr>
<td>1949</td>
<td>149.1</td>
<td>1,626</td>
<td>242,437</td>
<td>48,509</td>
<td>290,946</td>
<td>241,839</td>
<td>49,107</td>
</tr>
<tr>
<td>1950</td>
<td>147.8</td>
<td>1,610</td>
<td>237,958</td>
<td>49,107</td>
<td>287,065</td>
<td>244,564</td>
<td>42,501</td>
</tr>
<tr>
<td>1951</td>
<td>146.7</td>
<td>1,574</td>
<td>230,906</td>
<td>42,501</td>
<td>273,407</td>
<td>247,405</td>
<td>26,002</td>
</tr>
<tr>
<td>1952</td>
<td>145.6</td>
<td>1,721</td>
<td>250,578</td>
<td>26,002</td>
<td>276,580</td>
<td>250,279</td>
<td>26,301</td>
</tr>
<tr>
<td>1953</td>
<td>144.5</td>
<td>1,670</td>
<td>241,315</td>
<td>26,301</td>
<td>267,616</td>
<td>253,188</td>
<td>14,428</td>
</tr>
<tr>
<td>1954</td>
<td>143.5</td>
<td>1,594</td>
<td>228,739</td>
<td>14,428</td>
<td>243,167</td>
<td>256,132</td>
<td>12,965</td>
</tr>
<tr>
<td>1955</td>
<td>142.6</td>
<td>1,659</td>
<td>236,573</td>
<td>-12,965</td>
<td>223,608</td>
<td>259,112</td>
<td>-35,504</td>
</tr>
<tr>
<td>1956</td>
<td>141.7</td>
<td>1,770</td>
<td>250,809</td>
<td>-35,504</td>
<td>215,305</td>
<td>262,129</td>
<td>-46,824</td>
</tr>
<tr>
<td>1957</td>
<td>141.1</td>
<td>1,873</td>
<td>264,280</td>
<td>-46,824</td>
<td>217,456</td>
<td>265,608</td>
<td>-48,152</td>
</tr>
<tr>
<td>1958</td>
<td>140.4</td>
<td>2,159</td>
<td>303,124</td>
<td>-48,152</td>
<td>254,972</td>
<td>268,862</td>
<td>-13,890</td>
</tr>
</tbody>
</table>
the area in which the stability of livestock operations would require stabilization of feed grain supplies. To avoid some problems of managing the stocks as well as to permit intraannual price variation to reflect some of the storage costs, the storage rules might involve purchase at $1.90 and sale at $2.10 per hundredweight with appropriate geographic differentials to encourage storage in the area mentioned above. Effective outlook information would be required to keep cattle and hog production rates consistent with demand, and thereby avoid short-run over- or under-utilization of feed supplies. This would not be an automatic result induced by the stabilization program.

The analysis of information contained in Table 10 indicated a surplus of about 10 million acres of average productivity feed grain land and about 20-25 million tons of carryover stocks. The issue of leguminous forage production as a part of the rotation plans of feed grain producers will be avoided by stating that land requirements for such production should be analyzed separately and that, with commercial fertilizers, feed grain production can economically eliminate the legume hays as part of the rotation pattern. With this viewpoint, we shall estimate in a crude fashion the actual acreage magnitudes that might be required to secure a 10 million acre reduction of average productivity land for feed grains. This does not involve acreage reductions for wheat or cotton.

Approximately 28.5 million acres are currently under Soil Bank contracts in the U. S. A relatively small percentage of this acreage would represent land continuously used in feed grain production—practically a negligible reduction in basic capacity. Since a frequency distribution of productivity classes of land being used in feed grain production is not available, we shall assume an arbitrary distribution for illustrative purposes. The previous trend function would indicate that land of average productivity (a statistical average) would be capable of producing currently about 36 bushels per acre of corn equivalent. In a macro sense, let us assume that 40 percent of the feed grain land currently has an average productivity of 15 bushels per acre, 50 percent has an average productivity of 45 bushels per acre, and 10 percent has an average productivity of 75 bushels per acre. Let us further assume that these average micro units have a symmetric triangular distribution of 30 bushels range centered on the average yield rates.

We shall attempt to ascertain how many acres would need to be retired to secure the 360 million bushel reduction in productive capacity under two alternatives. First, let us assume that all of the reduction would come from retirement of whole farms in the lowest productivity class. This would require about 24 million acres.

Second, let us assume that a mandatory percentage reduction in feed grain acreage was imposed on each farm. We shall assume that the operator's decision would be to retire the least productive acreage. With an assumed based acreage of 150 million acres distributed as 60
million, 75 million, and 15 million acres across the productivity classes, a reduction of approximately 9.47 percent would be required. This would total about 14.2 million acres.

Summarizing, (1) if land of “average” productivity could be uniformly retired, a reduction of 10 million acres or about 6.7 percent would be required, (2) if land of the lower productivity class were uniformly retired on a whole unit basis, a reduction of 24 million acres, or about 16.0 percent, would be required, and (3) if a mandatory percentage reduction were imposed, a rate of about 9.47 percent would be required and would amount to about 14.2 million acres. These are all illustrative computations and do not necessarily reflect actual circumstances except in a qualitative ordering.

The discussion just concluded had reference to the analysis of a single acreage reduction at a point in time. It should be obvious that the estimation of projected land requirements, after a reduction has been accomplished, cannot logically be based on the aggregate productivity trend function previously used unless the procedure of reduction uniformly reduced all classes of land in the same proportion. Any program (such as those considered earlier) that changed the proportions of the productivity classes for the new base acreage could have a significant effect on the projected trend in yield per planted acre.

To point out more specifically the implications of the issues raised in the preceding paragraph, we shall continue to frame the problem and develop an answer from partially synthetic arguments. Let us assume the three unique land classes (low, average, high productivity) in the previously stated initial proportions of 40, 50, and 10 percent respectively. Each of these land classes will be assumed to have a linear productivity trend function of the form, \[ T_i = a_i + b_i t. \]

The overall trend function may be stated as \[ W_t = a + b t, \] and is equivalent to \[ \sum_{i=1}^{3} p_i (a_i + b_i t). \] Consequently, the following relationships are involved:

(1) \[ .40 a_1 + .50 a_2 + .10 a_3 = a = 1,589.566 \]
(2) \[ .40 b_1 + .50 b_2 + .10 b_3 = b = 32.49, \] where the values for “a” and “b” are taken from the previously estimated trend function, with \( t = 0 \) for the 1948 crop year.

Unique solutions for \( a_1, a_2, a_3 \) and \( b_1, b_2, b_3 \) are possible only if the relative sizes of the a’s and the relative sizes of the b’s are specified. We shall assume \( a_1 : a_2 : a_3 \) proportional to 1:3:5, since they represent a set of “level” parameters for yields and are consistent with the assumed current yield rates of 15, 45, and 75 bushels of corn equivalent per acre. With the land class proportions of 40, 50, and 10 percent, these assumed yields give an overall average of 36 bushels per planted acre. The historic trend function reaches this level for the 1961 crop year. The assumed conditions are therefore consistent with the present estimated average yield levels.

\[ * \]
Case I. $b_1 = b_2 = b_3 = b = 32.49$

This is equivalent to assuming the same absolute productivity increases for all classes of land.

Case II. $b_1 : b_2 : b_3 = 1 : 3 : 5$

This assumes that absolute productivity increases per year are proportional to yield rates per planted acre between the land classes. Although a reasonable assumption for 10 to 20 years ago, it may not be particularly relevant for the near future.

Case III. $b_1 : b_2 : b_3 = 1 : 2 : 1$

This assumes that low and high productivity classes of land have equal rates of productivity increase but at only half the level of the average land class. This assumes that current technology has failed to be used as fully as possible, mostly on average quality land, and that new techniques will have equivalent increasing effects on all land classes.

Solutions under these assumptions are:

Case I.

$$W_{1t} = 662.319 + 32.49 t$$
$$W_{2t} = 1,986.958 + 32.49 t$$
$$W_{3t} = 3,311.596 + 32.49 t, t = 0 \text{ for 1948 crop year}$$

Case II.

$$W_{1t} = 662.319 + 13.54 t$$
$$W_{2t} = 1,986.958 + 40.61 t$$
$$W_{3t} = 3,311.596 + 67.69 t, t = 0 \text{ for 1948 crop year}$$

Case III.

$$W_{1t} = 662.319 + 21.66 t$$
$$W_{2t} = 1,986.958 + 43.32 t$$
$$W_{3t} = 3,311.596 + 21.66 t, t = 0 \text{ for 1948 crop year}$$

Armed with these productivity class trend functions for yields per planted acre, we can easily compute the acreage requirements when adjustments involve only acreages in the low productivity class. Knowing the estimated total feed grain demand projections and the projected total supply from a fixed acreage of average and high yielding land, the difference must be met by the low quality land whose yield rate is given by $W_{1t} = a_1 + b_1t$ under the different cases assumed. Table 11 gives the results of these computations for projections I and II.
Table 11. Estimated Low Productivity Land Requirements in Millions of Acres in Feed Grain Productions\(^a\) (U. S. 1959-1969 Crop Years)

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Projection I Case I</th>
<th>Case II</th>
<th>Case III</th>
<th>Projection II Case I</th>
<th>Case II</th>
<th>Case III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>42.3</td>
<td>37.7</td>
<td>39.9</td>
<td>42.1</td>
<td>37.6</td>
<td>39.8</td>
</tr>
<tr>
<td>1960</td>
<td>42.8</td>
<td>38.1</td>
<td>40.4</td>
<td>41.6</td>
<td>36.5</td>
<td>38.9</td>
</tr>
<tr>
<td>1961</td>
<td>43.5</td>
<td>38.6</td>
<td>41.0</td>
<td>41.0</td>
<td>35.4</td>
<td>38.2</td>
</tr>
<tr>
<td>1962</td>
<td>44.1</td>
<td>39.2</td>
<td>41.6</td>
<td>40.5</td>
<td>34.4</td>
<td>37.4</td>
</tr>
<tr>
<td>1963</td>
<td>44.8</td>
<td>39.8</td>
<td>42.3</td>
<td>40.0</td>
<td>33.5</td>
<td>36.7</td>
</tr>
<tr>
<td>1964</td>
<td>45.5</td>
<td>40.5</td>
<td>43.0</td>
<td>39.6</td>
<td>32.6</td>
<td>36.1</td>
</tr>
<tr>
<td>1965</td>
<td>46.3</td>
<td>41.3</td>
<td>43.8</td>
<td>39.2</td>
<td>31.7</td>
<td>35.5</td>
</tr>
<tr>
<td>1966</td>
<td>47.0</td>
<td>42.1</td>
<td>44.6</td>
<td>38.8</td>
<td>30.8</td>
<td>34.9</td>
</tr>
<tr>
<td>1967</td>
<td>47.8</td>
<td>43.0</td>
<td>45.5</td>
<td>38.5</td>
<td>30.0</td>
<td>34.3</td>
</tr>
<tr>
<td>1968</td>
<td>48.6</td>
<td>44.0</td>
<td>46.4</td>
<td>38.1</td>
<td>29.3</td>
<td>33.8</td>
</tr>
<tr>
<td>1969</td>
<td>49.5</td>
<td>45.1</td>
<td>47.3</td>
<td>37.9</td>
<td>28.6</td>
<td>33.4</td>
</tr>
</tbody>
</table>

\(^a\)Assumes 75 million acres of average quality land and 15 million acres of high quality land are fixed over time. All adjustment takes place uniformly within the low quality land class, initially fixed at 60 million acres.

Continuing with our synthetic basis, let us next consider the situation under a mandatory percentage reduction (or expansion) program. We will again assume a base acreage of 150 million acres distributed as 60, 75, and 15 million acres across the productivity classes. The average micro unit in each class will be assumed to have an internal land quality distribution that can be depicted as a symmetric triangle centered on the estimated average trend yield at each point in time and having a constant range of 840 pounds per acre below and above the expected average yield.\(^{10}\) A universal decision by operators to adjust acreage on the lower quality land under their control will be imposed.

We shall compute the acreage requirements for crop years 1959-69 inclusive for the two projections on total demand and the three cases for productivity trends by land classes. These acreage requirements will be in terms of the percentage of the initially assumed base acreage of 150 million acres. Consider the following at a point in time:

Let, \(D_t = .82 Q_t\) be the estimated total demand for feed grains

\(W_{it} = \) the expected yield per planted acre for the \(i\)th class of land (differs by case being considered)

\(A_{it} = \) initial acreage in the \(i\)th class of land

\((A_{10} = 60, A_{20} = 75, \text{ and } A_{30} = 15 \text{ million acres})\)

\(X_t = \) distance to the right from the lower end point of the internal frequency distribution of land productivity for each of the three major classes (measured in pounds per planted acre)

\(^{10}\) In the computations for Table 12, we ignored the fact that the internal distribution for the low quality land had a very small part of the lower tail in the negative region of yields for crop years 1959-61 inclusive.
Then,

\[ \sum_{i=1}^{3} A_{i0} \left( \frac{X_t^3}{2(840)^2} \right) \left( \frac{2}{3} X_t + (W_{it} - 840) \right) = \sum_{i=1}^{3} A_{i0}W_{it} - D_t \]

or

\[ X_t^3 + X_t^2 \left( \sum_{i=1}^{3} A_{i0}W_{it} - 1260 \right) \left( \frac{100}{100} \right) = 14,112 \left( \sum_{i=1}^{3} A_{i0}W_{it} - D_t \right) \]

must hold. Solution for \( X_t \) is by trial and error.

After the value of \( X_t \) is computed, the percentage reduction required is given by \( 100 \frac{X_t^2}{2(840)^2} \). Values given in Table 12 are 100 minus the percentage reduction. All percentages have reference to the initial base acreage. Year by year percentage adjustments could be computed from these fixed base percentages. All cases of alternative land class productivity trend alternatives have the same solution because each case was computed to be consistent with the overall trend function. Consequently, only one column is required under each of the projections of demand for feed concentrates. The treatment of this adjustment program has ignored the fact that some of the units in production have complied with acreage allotments at least partially in an effective sense.

Analyses to this point in this section have been based on the feed concentrate demand outlook of the previous section which predicted a very minor increase in the export market. We believe this position is supportable, unless a major change in public policy related to foreign economic development is forthcoming. Should the U. S., in cooperation with other nations, initiate a long-run plan for the economic development of many areas of the world, the situation of surplus

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Projection I (%)</th>
<th>Projection II (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>91.0</td>
<td>91.0</td>
</tr>
<tr>
<td>1960</td>
<td>91.2</td>
<td>90.6</td>
</tr>
<tr>
<td>1961</td>
<td>91.5</td>
<td>90.3</td>
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<tr>
<td>1962</td>
<td>91.7</td>
<td>90.0</td>
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<td>1963</td>
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<td>1967</td>
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<td>1968</td>
<td>93.8</td>
<td>88.5</td>
</tr>
<tr>
<td>1969</td>
<td>94.2</td>
<td>88.4</td>
</tr>
</tbody>
</table>

*Base acreage is 150 million acres distributed as 60, 75, and 15 million acres of low, average, and high quality land. Reduction is mandatory on individual units, and is assumed to be taken from the lower quality land on each unit.*
capacity in American agriculture could evaporate. This assumes that the U. S. commitment could be around $15-20 billion dollars per year and that part of the program would be a planned tie-in of agricultural supplies from the U. S. as capital offsets for the recipient nation in the other areas of capital requirements.

IMPLICATIONS FOR INTERREGIONAL COMPETITION AND TRANSPORTATION POLICY

Adequate treatment of the subject of this section would require spatial disaggregation of the basic model. This will not be accomplished in this report. Many of the more fundamental aspects of interregional competition can be appraised satisfactorily without resorting to explicit spatial details about the specific levels of demand and supply.

The principal realities that are basic to more specific appraisal of the spatial and form problems of the livestock-feed economy are:

1. The major surplus supply area for feed concentrates is in the Midwest, approximately equivalent to the North Central Region, excluding Wisconsin and Michigan.
2. Two major excess demand areas are the Pacific Coast Region and the combination of Michigan, Wisconsin, and the North Atlantic Region.
3. Three other excess demand areas are the South Atlantic, South Central, and Mountain Regions.
4. The basic beef range area of surplus supply includes the Mountain and Great Plains Regions.

Let us appraise certain aspects of the beef sector alone—later we shall reflect the interdependence with the other animal classes. Consider the issue of competition between beef finishing operations in California and eastern Nebraska. We are interested in the factors which influence this interregional competition and the circumstances under which one or the other region would be dominant, i.e., have lower, not equal supply costs. Associated with the feedlot competition are factors that determine whether interregional shipments are in live or processed form (if either can take place competitively) and consequently the location of slaughtering activities. Figure 2 provides a visual aid for the discussion to follow.

We shall assume linear transportation costs; that all local transportation costs, nonfeed feedlot costs, and slaughtering costs are equal (this is not essential, but differences are probably small and qualitative statements can be made later to account for such differences); that California is deficit in feed grains; that feeders of “w” pounds are
finished to W pounds in both areas; and that the total distance between California and Nebraska points is fixed. The following definitions are required:

\[ D = \text{distance between California and Nebraska points (miles)} \]
\[ X = \text{distance to competitive margin of feeder supply from Nebraska feedlots (miles)} \]
\[ D - X = \text{distance to feeder supply margin from California feedlots (miles)} \]
\[ p_{1w}'' = \text{feeder price at margin for w weight class (cents per pound)} \]
\[ w = \text{feeder weight (pounds)} \]
\[ W = \text{slaughter animal weight (pounds)} \]
\[ c_1 = \text{pounds of feed grain per pound of gain} \]
\[ k_1 = \text{pounds of carcass per pound of live weight slaughtered} \]
\[ t_{1}' = \text{transportation cost on feeder (cents per pound per mile)} \]
\[ t_{1}'' = \text{transportation cost on slaughter animal (cents per pound per mile)} \]
\[ t_1 = \text{transportation cost on beef carcasses (cents per pound per mile)} \]
\[ T = \text{transportation cost on feed grain (cents per pound per mile)} \]
\[ P = \text{feed grain price in Nebraska} \]

First, let us dispose of an alternative that is not shown on the diagram, namely, ship the feed grain to the feeder animals at the range point, finish, and then either ship finished animals to distant slaughter points or slaughter them in the range area and ship the carcasses, depending on which is lower \( t_{1}' \) or \( k_1 t_1 \). Assume for the moment (to be proved shortly) that California feedlots can compete with Nebraska feedlots on imported grain and at a point \( D - X \) for feeder animals. We shall now compare whether this form of operation has a smaller supply cost than the alternative stated at the beginning of this paragraph. Algebraically, under what conditions is \( p_{1w}''w + w t_{1}''(D - X) + c_1 (W - w) (P + TD) \) less than \( p_{1w}''w + c_1 (W - w) (P + TX) + k_1 W t_1 (D - X) \) (assuming for the last term that \( k_1 t_1 < t_{1}' \))? After sim-
plification, this is equivalent to whether \( w (t''_1 - c_T) \) is less than \( W (k_t t_1 - c_T) \). Normally, \( k_t t_1 \) would be either less than or about equal to \( t''_1 \). With \( W \) being from 1½ to 2 times larger than \( w \), and \( c_T \) being larger than either \( t''_1 \) or \( k_t t_1 \), we should expect the inequality to be reversed. Consequently, according to this analysis, range finishing would appear to be a dominant procedure over finishing in California. The limiting factor on its realization, however, is the shortage of complementary roughage such as hay and silage in the range areas. Therefore, we shall conclude that this potential is limited in scale to certain irrigated areas in the range country and in aggregate cannot eliminate the other alternatives depicted in the previous diagram. Inshpishment of the roughage would be prohibitive.

Let us now assume \( k_t t_1 < t''_1 \) and continue our analysis of the Nebraska-California competition in beef supply to the Pacific coast. If we equate supply costs at the California level and are able to solve for a positive value of \( X \) less than \( D \), then marginal supplies are feasible from both areas and without specific demand functions and range area density data no specific magnitudes can be stated. However, if the animal volume west of the equilibrium boundary point is large enough to meet total West Coast demand, no volume would enter from the Midwest.

The basic equilibrium condition is:

\[
P_{1w}''w + wt''_1 X + c_T (W - w) P + k_t W t_1 D = P_{1w}'' (D - X) + c_T (W - w) (P + TD)
\]

or,

\[
2wt''_1 X + k_t W t_1 D = wt''_1 D + c_T (W - w) TD
\]

Solving for \( X \) we have

\[
X = \frac{D}{2} \left( 1 + \left[ \frac{W}{w} \left( \frac{c_T - k_t t_1}{t''_1} \right) - \frac{c_T t''_1}{t''_1} \right] \right)
\]

Notice that \( X \) becomes larger as \( \frac{W}{w} \) becomes larger. This implies that the greater strength of California feedlot competition lies with the feeding of heavy feeders—perhaps above 700 pounds. However, the cheapening of calves on winter and spring foothill ranges reduces some of the disadvantages of lighter weight feeders.

Current transportation costs indicate that \( T = .55 \) \( t''_1 \) and \( k_t t_1 = .90 \) \( t''_1 \). Let us further assume \( W = 1,000 \), \( w = 750 \) and \( c_T = 7.0 \). Upon substitution of these values we secure the result that \( X = .54D \), indicating a point about midway between Nebraska and California.

It must be recognized that by-products of fruit and vegetable processing plants are used in rations in California. This might be assumed to reduce the value of \( c_T \) to about 6.0 in terms of imported feed grain equivalent. If the supply costs are computed on this basis, the solution for \( X \) would be \( X = .45 D - \frac{1}{3t''_1} \), when \( P = 2.00 \) cents

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per pound. Since $t_1''$ is approximately .0011 cents per pound per mile, the latter term is about $-300$ and with $D = 1,600$, $X = 720 - 300 = 420$ miles. This would place the competitive boundary in the Great Plains area and would be consistent with the fact that the Denver market is becoming primarily a part of the western supply area in recent years.

Finally, notice that as $X$ increases, the comparative advantage for the Midwest suppliers increases. The following statements can be made: (1) if $c_1$ is lowered (improved beef conversion rates), then $X$ is decreased, (2) if $T$ increases, then $X$ increases, (3) if $t_1$ increases, then $X$ decreases, and (4) if $t_1''$ increases, then $X$ decreases. Usually, $T$, $t_1''$, and $t_1$ would move proportionately at the same time and would therefore leave $X$ unchanged if conversion rates were uniform.

The previous discussion indicated several conditional aspects of interregional competition that can be analyzed without developing the full equilibrium allocation details. We will now turn to a consideration of major factors that determine the geographic structure of the livestock-feed grain economy. Two basic problems are involved as well as numerous secondary problems—all in a simultaneously determined system. The basic issues are the pricing and allocation patterns for the primary products—range cattle and feed grains. Secondary issues are the suballocations of feed grains to the animal classes, the location of the feed conversion activities and the location of animal processing activities. These latter issues involve the interregional movement of grain and animal products and involve the determination of the competitive location of marketing facilities.

Let us simplify reality by considering the collinear approximation shown in Figure 3. This depicts two excess demand points for the eastern and western areas of the U. S., a dispersed section of excess range cattle supply, and a section of excess feed grain supply. We assume the equilibrium marginal position shown for eastern and
western allocations of the range cattle, and seek to show the allocation pattern for the feed grain sector.

In equilibrium, the lowest price for range cattle would be at the indicated boundary. Prices at other points would be above this price by the magnitude of transportation costs from the boundary. This gradient in feeder cattle prices has an effect on the gradient for the net value of feed grain used in beef finishing operations. We shall assume that the transportation cost on beef carcasses is lower than the equivalent live animal rate per pound of beef. This is consistent with nearly all current rate structures in the U. S., and especially so for interregional shipments.

Let us now derive the net value gradient for feed grain in the beef finishing operation. In terms of the supply cost for beef, we have at a point in the market that, value of 1 lb. beef = value of \(\frac{w}{k_1 W}\) lbs. of feeder + value of \(\frac{c_1 (W-w)}{k_1 W}\) lbs. of grain + \(K_w\), where \(K_w\) is the sum of slaughtering costs (minus by-product values) and other feedlot costs per pound of carcass beef.

For a given value of \(w\) we have as a solution for the grain value,

\[
\text{value of 1 lb. grain} = \left(\frac{k_1 W}{c_1 (W-w)}\right) \left(\text{value of 1 lb. beef}\right) - \left(\frac{w}{c_1 (W-w)}\right) \left(\text{value of 1 lb. feeder}\right) - \frac{K_w k_1 W}{c_1 (W-w)}.\]

Let us refer beef values to the eastern market point and consider \(y\) as the distance from the eastern market. Let \(P_{1E}\) be the equilibrium beef carcass price per pound at the eastern market and \(P_{1w}''\) be the feeder price per pound at the range boundary point. Then, if \(y \leq M - m\),

\[
P_{1y}^* = \left(\frac{k_1 W}{c_1 (W-w)}\right) \left(P_{1E} - t_1 y\right) - \left(\frac{w}{c_1 (W-w)}\right) \left(P_{1w}'' + t_1'' [M-m-y]\right) - \frac{K_w k_1 W}{c_1 (W-w)}.\]

The slope of this net value function for grain would be

\[
\frac{dP_{1y}^*}{dy} = - \left(\frac{k_1 W}{c_1 (W-w)}\right) t_1 + \left(\frac{w}{c_1 (W-w)}\right) t_1'' \text{ and if } y > M - m, \text{ then the last term on the right would be negative also. This means that a kink occurs in the net value function for grain at the range boundary point. A similar but reversed result would occur if the western market point had been the reference for beef values.}

Before considering similar problems for the development of net value grain gradients for other uses, we should evaluate \(P_{1y}^*\) and \(\frac{dP_{1y}^*}{dy}\)

\[\text{11 Logically there would be multiple boundaries by weight classes, with the light weight class boundary to the west of heavier weight class boundaries.}\]
relative to various magnitudes for \(w\). Although the feedlot component of \(K_w\) will tend to increase for small values of \(w\), the last term of \(P_{1w}\) would decrease for small values of \(w\). The first term would decrease as \(w\) decreased but not as rapidly as the second term. Consequently, the value of \(P_{1w}'\) should tend to be high for small values of \(w\) and small for large values of \(w\). This is consistent with the fact that calf prices tend to be higher than prices for heavier feeders. The value of \(\frac{dP_y^*}{dy}\) would tend to be less negative (and could actually shift to a positive magnitude) as \(w\) increased. This implies that feedlots in the western cornbelt should have a comparative advantage in feeding heavier feeders and placement of lighter weight feeders should be to the comparative advantage of cattle feeders farther east.

The net value gradients for feed grain productivity in the other animal use categories are more easily determined, because the type of interdependence between the grain usage and the feeder animal found in the beef usage case is absent. In general, the solution for the slope of the grain value function related to distance from the eastern or western markets is given by 

\[
\frac{dP_{1g}^*}{dy} = \frac{k_i t_i}{c_i},
\]

where \(k_i\) is the product conversion factor, \(c_i\) is the grain conversion factor, and \(t_i\) is the transportation rate per unit of distance for the converted product form. A few changes are made in the conversion factor relationships previously used for eggs, pork and for milk for manufactured dairy products. The egg case is transformed to a poundage basis by assuming an average weight of 1.5 pounds per dozen. The dressing percentage for hogs is now set at 65 percent to account for the entire carcass—earlier analysis were only interested in the yield, excluding lard. Conversion factors for manufacturing butter, cheese, whole milk powder, and evaporated milk are stated since they have a significant bearing on the location aspects of the manufactured dairy products industry. Ice cream is omitted on the basis of assuming the orientation of manufacturing will be near the consumer—and to avoid the complications of the multitude of ingredient forms employed in its production.

Table 13 gives the values of the conversion factors, estimated relative transportation rates with the grain rate as the basis, and the relative slopes of the grain value productivity functions per unit of distance. These relative magnitudes are the key to the spatial allocation of the grain supply in the surplus region, provided other forces do not negate their significance. Usage categories with a relative slope greater than one should be most economically located near the excess demand and operate on imported grain. All usage categories having a relative value gradient less than one, should be most economically located in the surplus feed grain supply area with the processed animal products moving to the excess demand areas.
Table 13. Basic Conversion Factors, Relative Transportation Rates, and Relative Value Gradients for Feed Grains by Usage Categories

<table>
<thead>
<tr>
<th>Use Category</th>
<th>Grain Conversion Factor</th>
<th>Product Conversion Factor</th>
<th>Estimated Relative Transportation Rate (Based on Grain Rate)</th>
<th>Relative Value Gradients (Based on Grain Gradient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct grain</td>
<td>...</td>
<td>1.00</td>
<td>T</td>
<td>-1.00 T</td>
</tr>
<tr>
<td>Beef finishing</td>
<td>7.00</td>
<td>.55</td>
<td>$t_1 = 2.8T$</td>
<td>-.20 T or -.71 T (for w = 400)</td>
</tr>
<tr>
<td>(W = 1,000)</td>
<td></td>
<td></td>
<td>$t_1'' = 1.8T$</td>
<td>.07 T or -.36 T (for w = 800)</td>
</tr>
<tr>
<td>Hog production</td>
<td>5.00</td>
<td>.65</td>
<td>$t_2 = 2.5T$</td>
<td>-.32 T</td>
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<tr>
<td>Broiler production</td>
<td>3.50</td>
<td>.70</td>
<td>$t_3 = 3.0T$</td>
<td>-.60 T</td>
</tr>
<tr>
<td>Turkey production</td>
<td>5.50</td>
<td>.77</td>
<td>$t_4 = 3.0T$</td>
<td>-.42 T</td>
</tr>
<tr>
<td>Egg production</td>
<td>4.67</td>
<td>1.00</td>
<td>$t_5 = 2.5T$</td>
<td>-.54 T</td>
</tr>
<tr>
<td>Fluid milk usage</td>
<td>.33</td>
<td>1.00</td>
<td>$t_6 = 2.8T$</td>
<td>-8.48 T</td>
</tr>
<tr>
<td>Mfg. milk products</td>
<td>.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butter</td>
<td>.05</td>
<td></td>
<td>$t_B = 2.8T$</td>
<td>-.42 T</td>
</tr>
<tr>
<td>Cheese</td>
<td>.10</td>
<td></td>
<td>$t_C = 2.8T$</td>
<td>-.85 T</td>
</tr>
<tr>
<td>Evap. milk</td>
<td>.50</td>
<td></td>
<td>$t_E = 2.0T$</td>
<td>-3.03 T</td>
</tr>
<tr>
<td>Whole milk pwd.</td>
<td>.08</td>
<td></td>
<td>$t_w = 2.0T$</td>
<td>-.48 T</td>
</tr>
</tbody>
</table>

*The two values given for each value of w refer to the points before and after passing the boundary point for the range allocation of the beef cattle.

Study of Table 13 would indicate that only production of milk for fluid usage and for production of evaporated milk have relative value gradients for feed grains greater than one and should tend to be consumer oriented. In general, this is the situation for fluid milk, but somewhat less so for evaporated milk production. Plant and assembly economies of scale would tend to push evaporated milk plants away from excess demand areas if milk production density were unsatisfactory. This factor, in conjunction with the realities of classified milk pricing and zonal pricing of national and local brands of evaporated milk not completely consistent with transportation costs, tends to orient part of the industry to the surplus milk producing areas of the Midwest.

While discussing some of the variants of actual activities from expected locations, we may as well cover several others at the same time. More and more of the demand for shell eggs is shifting toward the AA grade. Under current procedures of assembly and shipment, it is merely impossible to move supplies very far and have a useable percentage of the volume in the AA grade. Consequently, a locational barrier exists for AA grade egg supplies and both coasts can therefore compete on imported feed in the production of the higher grades. Interregional competition will center on the lower grades of eggs. Improved handling and much greater egg production densities in the Midwest could conceivably break the spatial barrier.
Calculations for pork production treated the integral movement of the carcass as the practical basis. In reality, pork cuts apparently have rather low cross elasticity in comparison with the situation for beef cuts, and consequently most pork is processed by cuts at the slaughter point while most beef moves in whole or quartered carcass units. Furthermore, the relative demands for pork cuts are not uniform geographically and locations for comparative advantage in the shipment of some cuts may have disadvantages for other cuts. This, in conjunction with a very flat rate structure west from the Mississippi River on pork movements, could explain the absence of a concentrated West Coast pork supply area on the western fringe of the corn belt. One cannot discount the back-haul advantages of locations east of the Missouri River both for meat products and fruit or vegetable movements.

Broiler production operates with prepared feeds to a greater extent than pork or beef production. Consequently, much local hauling is involved even within the surplus grain producing area. This tends to reduce the comparative disadvantage of concentrated broiler production outside the surplus feed grain area. Climatic advantages and lower labor costs could dominate the transportation disadvantage. These factors are considered to be significant for explaining southern, eastern, and western broiler and turkey production concentrations. Certain economies of scale in processing and marketing would encourage dense concentrations of turkey operations—since the total demand level is relatively small and a zonal dispersion within the feed grain surplus area would tend to be too thin for the realization of these economies.

We should observe that the relative gradients other than for beef and pork operations are somewhat similar in magnitude. For these conversion activities differences in values for feed grain equivalent would be small as a function of distance. Consequently, the forces leading to distinct zonal usage of feed grains would not be strong and other factors could lead to a general dispersal or small concentrations. The existence of land in Wisconsin and Minnesota having good forage productivity but relatively poor feed grain producing ability leads to the relatively dense concentration of dairy operations in that area.

Having explained relevant bases for the existence of deviations of actual practices from the locational patterns of feed grain usage based only on transportation costs and conversion factors, we can now show these estimated equilibrium patterns. These allocations can be indicated only in a qualitative ordering, because the specific levels of demand and supply on a geographic basis would be required to secure explicit results. Figure 4 gives an example of the allocation patterns for the collinear model shown in Figure 3. The various regions of usage and the direction and form of product shipment are indicated for the surplus grain producing area only. The manufactured dairy product regions and the various poultry regions have been pooled in the draw-
Figure 4. Value Gradients and Utilization Patterns for Feed Grains in the Surplus Supply Area (Based on Figure 3)

Utilization Regions
1. Direct grain shipments to western market. Used for beef, dairy, poultry and egg production.
2. Beef finishing, shipment of carcasses to western market.
4. Hog production and shipment of pork products to western market.
5. Beef finishing (heavy feeders), shipment of carcasses to eastern market.
6. Beef finishing (light feeders), shipment of carcasses to eastern market.
7. Hog production and shipment of pork products to eastern market.
8. (Same as 3 but for eastern market)
9. (Same as 1 but for eastern market)

Implied price level differences have been graphically exaggerated for clarity purposes—actual differentials probably would not exceed 15 cents per bushel of corn equivalent over the surplus region or 50 cents per bushel nationally. Since actual transportation rates (not necessarily equivalent to costs) are extremely flat over the surplus grain area for distant shipments, there would be a tendency for all gradients to flatten and therefore lead to a general merging of the zones of utilization. Aggregate disequilibrium between the animal classes over time contributes to a continuous shifting of the relative advantages of the various grain uses and we should expect that actual use patterns would exhibit diversification instead of specialization in specific areas. The magnitude of short period disequilibrium in usage and returns to grain tends to camouflage the long-run comparative advantage for particular
areas. More order in aggregate production and marketing would be beneficial. Nevertheless, the feed grain economy's actual orientation is generally consistent with the estimated equilibrium pattern—especially for the beef and pork producing areas.

We shall now turn to a few considerations of transportation costs and their impact on the livestock-feed concentrate industry. No intensive treatment is intended. A series of statements will be made, some of which are supportable on the basis of information developed earlier in this report.

1. For the industry as a whole, increased transportation costs have two primary effects, namely, (a) tend to encourage increased production of the basic raw material (grain) in the deficit areas, and (b) tend to force adjustments in aggregate utilization (at a fixed grain price in the surplus area) or in grain price levels in the surplus grain area (if total utilization is fixed) on those categories of utilization having some price elasticity. We assume here that the transportation cost increases are general and do not shift the locational advantages of usage. The first effect is merely a reflection of the fact that all areas of an economic system tend to diversify if the transfer costs between areas create barriers to the realization of comparative advantages and interregional trade. It is very doubtful that conceivable increases in transportation costs could have a significant effect on the relative level of feed grain production in either the eastern or western deficit coastal areas—perhaps some increases might be visualized in the Pacific Northwest and South Central areas. The second effect would impinge on the beef, pork, and broiler categories of utilization.

2. It is in the interest of the industry and all consumers that transportation costs (rates) be as low as possible. Furthermore, arbitrary relative rates on grain, unprocessed animal products, and processed animal products are not in the best interest of farmers, marketing agencies, or consumers. These rates should reflect relative transportation costs as well as possible—including a recognition of interarea back-haul balances. The development of improved motor transportation and its inherent flexibility has done much to insure that relative transportation rates are reasonably consistent with a more direct evaluation of specific product movements. Stability of locational advantages for marketing agencies should be insured with stability of relative rates consistent with costs. Protection of vested interest in marketing facilities at specific locations or unfounded arguments on the assurance of greater competitive pricing should not be accepted as a long-run basis for arbitrary relative rates.

3. From the viewpoint of the Midwest surplus grain producing area, transportation rates on livestock and especially on meat
products should be as low as possible. These are the price elastic components of the derived demand for feed grains—although, even these categories are relatively inelastic. Nevertheless, the price and volume adjustments that are involved in the demand structure fall entirely within these areas. Lower transportation costs on meat products mean a higher net demand in the surplus area. Either price and/or volume of feed grains used can rise under these conditions. Considering the rate on grain shipments to deficit areas, we should note that the primary usages of such grain are in the categories of inelastic demand. Higher transportation rates (if economically justifiable) will not reduce the demand for this grain and therefore would not lower realized returns on grain in the surplus region. Rather, the increased rate would be passed on to consumers of fluid milk and high quality eggs in the form of higher prices. The impact on beef finishing in the West and broiler and turkey production in all deficit areas would result in an equivalent increase in similar utilizations within the surplus grain area so that no net loss in utilization or realized grain values would result. Consequently, arbitrarily low rates on feed grains should not be supported by Midwest producers. We assumed in this discussion that other rates were unchanged. Consumers of all products except fluid milk and high quality eggs (and perhaps broilers, if the deficit area producers would still have lower supply costs than producers in the grain surplus area) in the deficit areas should not experience any higher prices.
## APPENDIX

Some basic data not presented in the body of the report are listed here.

### Feed Grains—Planted Acres and Yields

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Planted Acres (Millions)</th>
<th>Yield (Tons/Planted Acre)</th>
<th>Crop Year</th>
<th>Planted Acres (Millions)</th>
<th>Yield (Tons/Planted Acre)</th>
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<tbody>
<tr>
<td>1937</td>
<td>154.3</td>
<td>.65</td>
<td>1949</td>
<td>147.6</td>
<td>.81</td>
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<tr>
<td>1938</td>
<td>150.7</td>
<td>.64</td>
<td>1950</td>
<td>151.3</td>
<td>.81</td>
</tr>
<tr>
<td>1939</td>
<td>150.1</td>
<td>.64</td>
<td>1951</td>
<td>143.6</td>
<td>.79</td>
</tr>
<tr>
<td>1940</td>
<td>150.1</td>
<td>.66</td>
<td>1952</td>
<td>139.1</td>
<td>.86</td>
</tr>
<tr>
<td>1941</td>
<td>150.6</td>
<td>.70</td>
<td>1953</td>
<td>140.7</td>
<td>.84</td>
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<tr>
<td>1942</td>
<td>157.5</td>
<td>.77</td>
<td>1954</td>
<td>155.5</td>
<td>.80</td>
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<tr>
<td>1943</td>
<td>162.2</td>
<td>.69</td>
<td>1955</td>
<td>157.8</td>
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<td>1944</td>
<td>163.4</td>
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<td>1945</td>
<td>153.4</td>
<td>.74</td>
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<tr>
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<td>144.6</td>
<td>.65</td>
<td>1959</td>
<td>154.6</td>
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<tr>
<td>1948</td>
<td>149.7</td>
<td>.90</td>
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### Poultry Data

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Average Laying Rate per Hen (Eggs)</th>
<th>Average Number of Hens on Hand (Thousands)</th>
<th>Broiler Production Retail Weight (Million Pounds)</th>
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<tbody>
<tr>
<td>1949</td>
<td>170</td>
<td>331,589</td>
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<td>1950</td>
<td>174</td>
<td>330,699</td>
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<td>1951</td>
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<td>339,540</td>
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<td>1952</td>
<td>181</td>
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<tr>
<td>1953</td>
<td>185</td>
<td>320,491</td>
<td>2,033</td>
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<tr>
<td>1954</td>
<td>188</td>
<td>312,086</td>
<td>2,265</td>
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<tr>
<td>1955</td>
<td>192</td>
<td>314,153</td>
<td>2,317</td>
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<tr>
<td>1956</td>
<td>196</td>
<td>309,104</td>
<td>2,989</td>
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<tr>
<td>1957</td>
<td>198</td>
<td>309,945</td>
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<tr>
<td>1958</td>
<td>201</td>
<td>304,826</td>
<td>3,854</td>
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<tr>
<td>1959</td>
<td>206</td>
<td>295,769</td>
<td>4,215</td>
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