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FORECASTING SHORT-RUN FED BEEF SUPPLIES WITH A SIMULATION MODEL

James N. Trapp*

Academic researchers have traditionally viewed forecast model development as an exercise in econometrics. The cornerstone of Econometric Forecasting models are the estimated own and cross price elasticities. In the case of supply forecasting, great emphasis has been placed upon estimating time-related elasticities of response through the use of various econometric distributed lag models. The theoretical focus of econometric models upon price response generally causes them to give very little direct attention to the physical attributes of the commodity being considered. Consideration, which is given to the physical attributes of the commodity, is in the form of specifying lag lengths in relation to biological production periods, using seasonal dummy variables, etc. The acceptable method of validating econometric forecasting models has been debated but generally is accomplished through theoretical arguments about the

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signs of the variables considered, review of the statistical significance of the parameters, and consideration of the R^2 value of the model or any of a host of other "tracking accuracy" measures.

The above described traditionally and professionally accepted rigorous approach to supply and demand forecasting is distinctly different than the presumed less rigorous methods often used by industry analyst, brokers, farmers, and extension outlook specialist. Indeed before the development and widespread use of computers to develop econometric models, much of our supply and demand forecasting was done in a different manner. Consider the pragmatic, layman-oriented approach to short-run fed beef forecasting which may be illustrated briefly as follows:

> Cattle have been going into the feedlot early this year because of poor pastures due to dry weather. These cattle are pretty thin. Normally you would expect cattle the weight of these to be on feed at least 180 days. But these cattle will likely put on weight fast because they are thin; and with this dry weather pushing corn prices up I expect slaughter weights will be down. So, if we don't have some cold weather in December or January I would expect to see fed cattle slaughter increasing a little earlier than normal next year.

The above forecasting rationale appears to be far removed from the "rigorous" econometric approach. Within the profession such rationale is generally reserved for coffee room conversations, "seat-of-the-pants" responses and use by extension personnel. While it may be granted that this approach contains significant amounts of economic logic and considers information often ignored in econometric models, it is readily dismissed as non-rigorous and undocumentable.

A problem with quickly dismissing this approach is the fact that it works - sometimes even better than the "rigorous" econometric approach. This fact is perhaps best evidenced by whom producers turn to for forecasts and even by whom the profession regards as leaders in supply outlook. Many of these people use a pragmatic physical approach to supply forecasting. Even if the approach is not superior, it has a certain inherent appeal to layman and producers because they can readily understand its logic. Price response parameters and distributed lag models are not the language of the layman and producer.

Intuitively, the layman forecaster sighted in the preceding example is describing the pertinent features of a beef growth simulation model (weight, body condition, weather, etc.) and making assumptions about rational management decisions (removing cattle from pastures because of poor conditions, changing slaughter weights in response to corn price changes, etc.) which would affect the nature of the growth process. In the past, the profession has generally chosen to not rigorously develop this approach to aggregage forecasting. This has likely been the case because data required by the approach were not available. In addition, the concepts of computerized simulation modeling have only been widely developed over the last decade.

The objectives of this paper are to describe the methodology developed for using a simulation model in making short-run fed beef supply forecasts and to illustrate the usefulness of such an approach. It is postulated that the approach presented provides an objective method of incorporating information and logic known by laymen, such as alluded to in the layman forecast example. In the past, such information and logic often has not been incorporated in econometric models. In addition the approach allows for interface with econometric models to estimate aggregate management decision responses to changing economic conditions. What is strived for is the development of a rigorous, documentable, and objective method of developing the layman or simulation approach to short-run fed beef supply forecasting. The methodology developed appears amenable to other supply forecasting efforts.

The Model

A number of beef animal growth models have been developed. Most of these models are based upon the work of Lofgreen and Garrett. Their work established an estimated relationship between beef growth and net energy consumption. Fox and Black, Gill, and Nelson have all developed fed beef animal growth simulators which expand upon the work of Lofgreen and Garrett. The model desired here, however, must be aggregate in nature and have a capability of maintaining records of the inventories of various weights of cattle on feed through time, as well as projecting their growth.

Nelson's model has been used as a starting point in this modeling exercise. However, Nelson's model and other beef growth models reviewed are far more complex than is deemed necessary or manageable for developing a generalized aggregate cattle on feed growth and inventory model. In addition, these models were not readily amendable to the inventory accounting process required. Fortunately, within the literature of continuous systems modeling, several computerized algorithms exist which are oriented to simulating population dynamics, i.e., birth, aging, cohert structure, and death. These models are aggregate in nature. With slight modification they can be altered to model feedlot entry, growth, weight coherts, and slaughter. The parameters required by such a modified dynamic population model are readily obtainable from applications of Nelson's beef growth simulator. Hence, by using Nelson's individual animal physical growth model to specify the parameters of a generalized aggregate population model, the physical detail of Nelson's model can be summarized in a meaningful manner that is compatible with an aggregate population model. In essence, the aggregate model requires only inputs describing the entry weight, exit weight, and average growth rate of each unique type of animal considered. Nelson's model can provide this and determine the impact of such factors as initial placement weight, body condition, sex, feed ration, etc. upon these parameters.

The basic structure of the aggregate growth and inventory fed beef population model developed is depicted in Figure 1. The model contains 17 inventory categories, three placement weight alternatives for steers, and three for heifers.[1] A uniform distribution of placement weights in each weight category is assumed, but the distribution

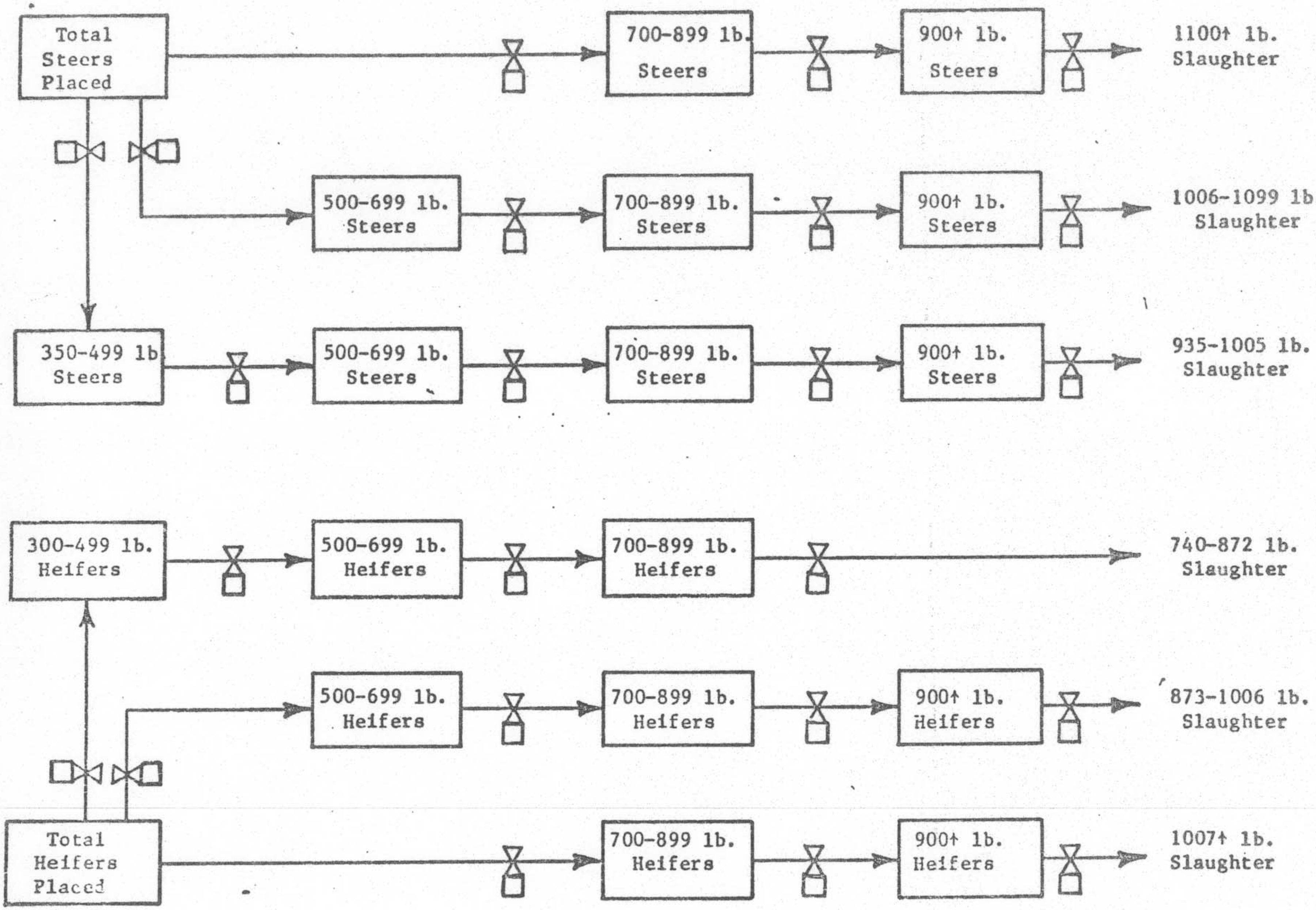

Figure 1. Fed Beef Population and Growth Model

of placements among categories is allowed to vary.

Each placement weight alternative results in a unique growth path and slaughter weight. Figure 2 depicts a typical set of growth paths and slaughter weights for steers placed at different weights.[2] A similar set of curves can be developed for heifers. Figure 2 was developed from Nelson's growth model and is postulated to be typical of English breeds of cattle fed in Midwestern feedlots.

Mayer et al. have provided evidence that the weight at which an animal grades choice, and hence would normally be slaughtered, is related to placement weight and days on feed. Data reporting the average placement weight and slaughter weight by pen of approximately 40,000 pens of cattle placed in over 100 commercial feedlots during 1977 and 1978 were analyzed in this study to quantity Mayer's observation. Results of a generalized least squares estimate of the relationship of placement weight and slaughter weight for the data set are presented in Table 1. They provide the basis for the specified weight to grade choice or typical slaughter weights depicted on the growth curves in Figure 1.

The inventory categories depicted in Figure 1 and the growth patterns and relationship depicted in Figure 2 have been modeled with a modified version of a dynamic population systems model. Specifically, a modified version of a continuous distributed delay subroutine developed by Pugh is used to implement the structure and information contained in Figures 1 and 2. The modified subroutine

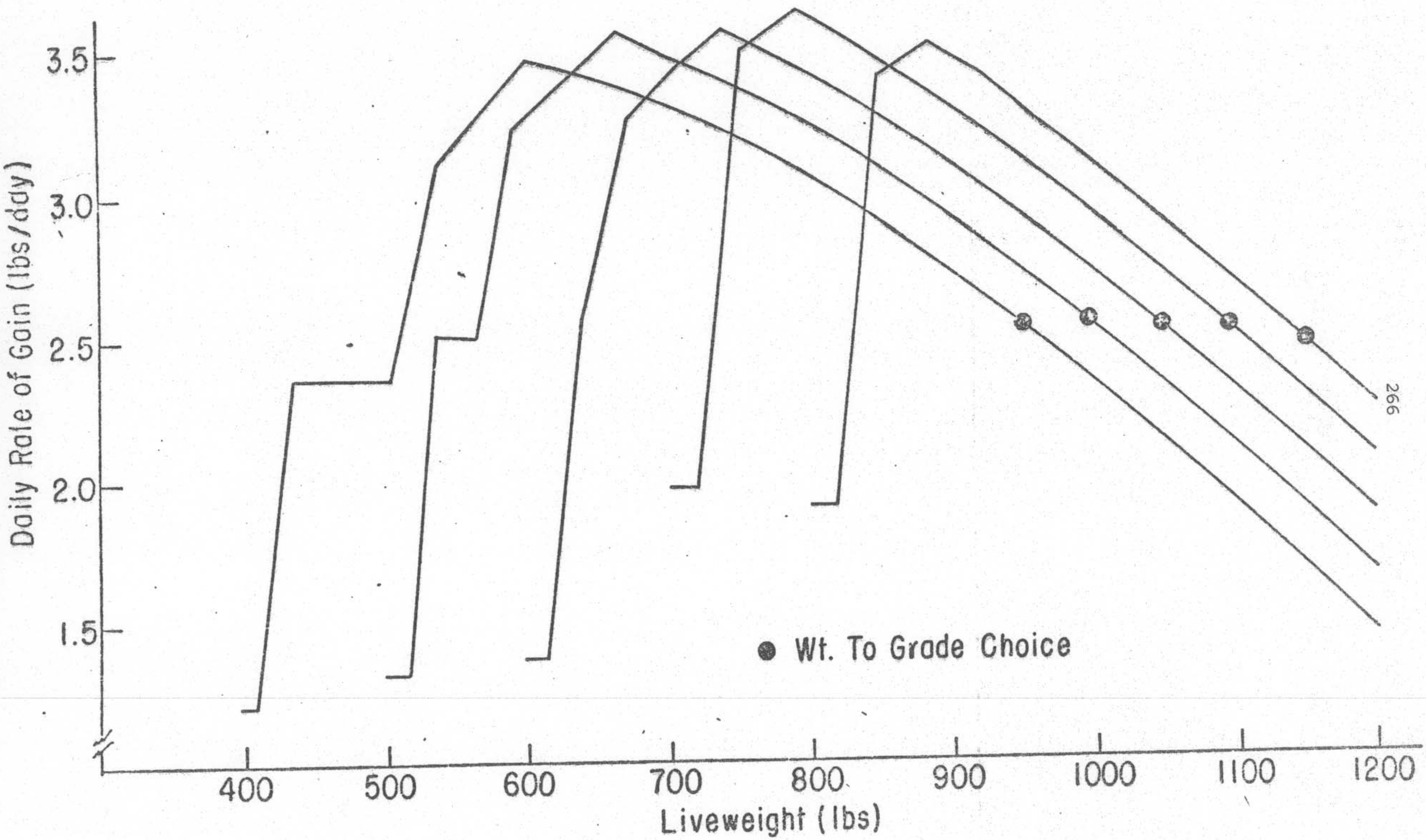

Figure 2. Typical Daily Rates of Gain for Steers by Placement Weight and Current Weight

Table 1. Average Steer and Heifer Placement Weights Regressed upon Average Steer and Heifer Slaughter Weights

Average slaughter weight of the pen (lbs./head)	Parameters[a]		
	Intercept	Average placement weight of the pen (lbs./head)	R^2
Steers	770.2 (94.7)	0.47 (39.1)	.99
Heifers	537.1 (57.1)	0.67 (41.6)	.99

[a]Values in parentheses are t-values.

developed is capable of simulating the daily flow of cattle into and out of each depicted inventory category and of maintaining an inventory count for each category. Parameters required to accomplish this include the average daily growth rate of animals in each inventory group, and the daily number and weight of animals entering the category. In essence, the fed cattle growth and inventory simulation model developed is a collection of 17 individual-distributed delay subroutine models linked together. For example, the simulated outflow of the delay model describing the 350-499 pound steer inventory category is the input to the delay model for the 500-699 pound steer inventory category in the lightest placement-weight growth path.

The growth curves depicted in Figure 2 for steers and a similar set of curves derived for heifers (from Nelson's model) are used to specify unique growth parameters for each of the 17 delay models such that the relative rates of growth between the inventory groups is maintained. The general rate of growth is allowed, however, to vary from season to season or year to year. Thus, a single valued shifter of the complex of curves depicted in Figure 2 is altered to reflect changes in growth rates over time.

Model Application

The model described in the previous section could be used to simulate or forecast future inventories and slaughter rates of fed beef, if several pieces of physical information about the aggregate fed beef population were known. For example, realistic forecasts could be made by operating the model if the current distribution of cattle on feed among the 17 inventory categories depicted were known and if future slaughter weights, growth rates, placement numbers, and placement weights could be predicted from past and/or current information. Most of this required information is not reported on an aggregate basis by any private or public institution. No information is publicly reported about growth rates and placement weights. Placements of cattle on feed are reported monthly. Inventories by 200-pound weight increments are reported quarterly. But these reports do not distinguish the sex of animals placed nor link the inventories to the placement weight as depicted in Figure 1. The relationships depicted in Figure 2 indicate that consideration of the inventory composition by placement weight is of significant importance.

Hence, application of the model in an aggregate forecasting framework based upon publicly reported data must be viewed as impossible or, without an objective means of obtaining such data, plausible only in a highly subjective and non-rigorous fashion.

Estimation of the unknown data series

Historical data series of the parameters required to operate the model in an aggregate forecasting mode can be objectively estimated. In essence, the structure of the model and reported data provide all but a few of the necessary parameters. The missing parameters required to simulate forecasts of cattle on feed inventories and marketings can essentially be reduced to three--the general growth rate, the placement weight distribution, and the sex of animals placed on feed. Intuitively, it seems possible to experiment with these parameters for any historical quarter to determine which set of parameters produces simulated values the most consistent with reported marketings and inventory numbers. In so doing, a set of historical values of the required unknown parameters could be developed which are uniquely oriented to use in the model for forecasting purposes. These data series would then provide a basis for specifying expected future values as required to make forecasts with the model.

The unknown data series desired can be systematically and objectively estimated by using existing non-linear optimization procedures. In using such a procedure, the unknown values are treated as time-varying parameters of a non-linear system. The optimization procedure, via heuristic search processes, can determine (estimate) the set of parameters which optimize any generalized forecasting accuracy function desired. The objective function specified in this case consists of the weighted sum of squared errors in predicting nine inventory levels, the total number of cattle on feed, and fed cattle marketed. This function is minimized each quarter to generate one set of time-varying parameter estimates.

$$(1)\quad OBJ = ESTEER^2(350\text{-}499) + ESTEER^2(500\text{-}699) + ESTEER^2(700\text{-}899) + ESTEER^2(900\text{-}1099) + ESTEER^2(1100 \text{ and above}) + EHEIF^2(300\text{-}499) + EHEIF^2(500\text{-}699) + EHEIF^2(700\text{-}899) + EHEIF^2(900 \text{ and above}) + 9 * EMARKET^2$$

where

OBJ = the sum of squared errors objective value to be minimized.

$ESTEER^2(I\text{-}J)$ = the square of the difference (error) between the reported and estimated numbers of steers on feed in weight category I-J, i.e., 499 pounds and below, 500-699 pounds, 700-899 pounds, 900-1,099 pounds and 1,100 pounds and above.

$EHEIF^2(I\text{-}J)$ = the square of the difference (error) between the reported and estimated number of heifers on feed in weight category I-J, i.e., 499 pounds and below, 500-699 pounds, 700-899 pounds and 900 pounds and above.

$ECOF^2$ = the square of the difference (error) between the reported and estimated numbers of cattle on feed at the end of the quarter.

$EMARKET^2$ = the square of the difference (error) between the reported and estimated numbers of fed cattle marketed during the quarter.

The error in estimating total cattle on feed is weighted nine times more than other errors since it is the summation of nine weight categories.

Estimation of the time-varying input parameters is conducted as a nonlinear optimization problem. (For a detailed discussion of this estimation procedure the interested reader is referred to Oklahoma State University Experiment Station Bulletin #739 entitled "illustrative Applications of Optimal Control Theory Techniques to Problems in Agricultural Economics" by Richardson, Ray and Trapp.) The nonlinear optimization algorithm used was developed by M. J. Box and is referred to as the "Complex Algorithm". It consists of a heuristic search procedure capable of finding the minimum or maximum value of a non-linear objective function subject to non-linear constraints.

To estimate a series of time-varying parameters, values for each quarter are considered in sequence. At the end of each quarter, any errors in estimating the size and weight distribution of the ending inventory of cattle on feed are corrected by using data reported in Cattle on Feed, hence, previous errors will not effect parameter estimates for the following quarter.

The simulation accuracy achieved with the growth and inventory model using the time-varying parameters estimated was quite good over the period 1960-1978. The R^2 for simulating the number of cattle on feed was .99 with an average percentage error of 1.57%. The largest single percentage error was 6.7%. The R^2 for simulating the number of cattle on feed marketed was .98 with an average percentage error of 2.86%. The largest single error was 14.17%.

Estimated Data Obtained

Operation of the model and optimization algorithm over the period 1960-1978 yielded time series estimates of placement weight, sex of animals placed, and average aggregate growth rates. Tables 2 and 3 report average seasonal patterns and annual averages for these data series over the period 1960-1978.

Growth rates are estimated to be most rapid in the first and fourth quarter and slowest in the third quarter. Seasonal fluctuation is due both to climatic factors and the type of backgrounding received by cattle placed at different seasons. The steer/heifer ratio (sex ratio) of cattle placed on feed indicates that proportionately fewer heifers are placed on feed in the first and fourth

Table 2. Selected Average Estimated Characteristics of Cattle on Feed and Placed on Feed by Quarter (1960-1978)

Quarter	Growth rate index	Sex ratio of cattle placed on feed steers/heifers	Average wt. of cattle on feed
1	104	3.20	815
2	100	2.15	834
3	89	1.92	821
4	105	2.24	768

Table 3. Estimated Seasonal Distribution of Average Weight and Numbers of Cattle Placed on Feed (1960-1978)

Quarter	Percent Placed: Under 500 lbs.	Percent Placed: 500-699 lbs.	Percent Placed: 700-899 lbs.	Average placement weight	Index of no. of cattle placed on feed
1	53.2	40.3	6.6	518	85
2	26.7	66.3	7.6	571	83
3	26.5	43.7	29.8	612	97
4	64.4	26.5	9.1	502	135
Annual average	42.2	44.5	13.2	549	100

quarters. Lastly, the estimates of the average weight of cattle on feed (which is not an estimated variable but a descriptive output of the model) indicates that the heaviest average weight of cattle on feed occurs in the second quarter and the lightest in the fourth. The seasonal pattern of the average weight of cattle on feed is correlated with the seasonal pattern for number of animals placed and with the average weight of animals placed.

The placement weight information generated by the model is perhaps the most useful. The estimates indicate that a significant portion of cattle placed weigh less than 500 pounds, i.e., 42.2% (Table 3). This is not surprising because the turnover rate of cattle on feed under 500 pounds is the most rapid of any reported weight group. Cattle typically gain only 50-75 pounds while in this weight classification, compared to 200 pounds in others. Hence, to maintain a given inventory of cattle on feed under 500 pounds requires more placements than to maintain the same inventory in other weight classes where the turnover rate is three to four times slower.

The estimates reported in Table 3 indicate the majority of the placements under 500 pounds occur during the first and fourth quarters. The heaviest average placement weights occur in the second and third quarters. The largest percentage of cattle (66%) placed in the second quarter is in the 500-699 pound weight range. This group likely consists of spring calves that have been wintered, grazed on spring pasture, and sent to feedlots.

The time series paths of the annual average values found for the estimated variables are presented in Figures 3A-3C. The sex ratio (Figure 3A) is correlated with the cattle cycle (Figure 3D) measured as the annual index of the rate of change in the size of the cow herd. The simple correlation coefficient (r) is +.67. The sex ratio appears to rise during periods of expansion because more heifers are held for replacements, thus, causing the steer/heifer ratio to rise.

The placement weight series is not strongly correlated with the cattle cycle but does appear to be cyclical. During 1974 and 1975 when feed prices were high relative to cattle prices and "grass fed" beef was common, estimated placement weights were the highest observed for the period from 1960-1978.

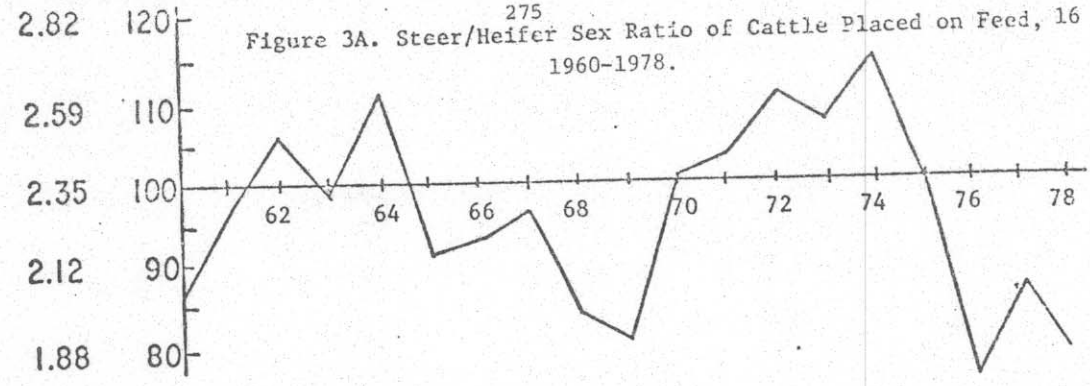

Figure 3A. Steer/Heifer Sex Ratio of Cattle Placed on Feed,[16] 1960-1978.

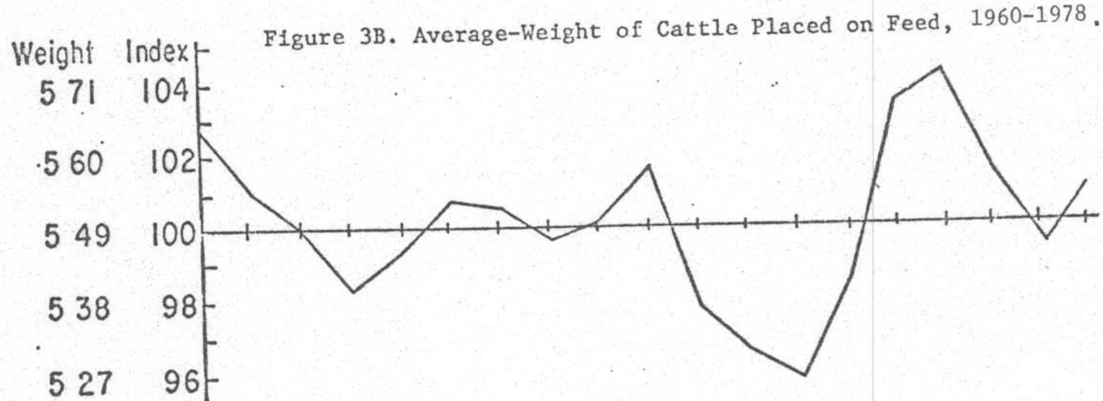

Figure 3B. Average-Weight of Cattle Placed on Feed, 1960-1978.

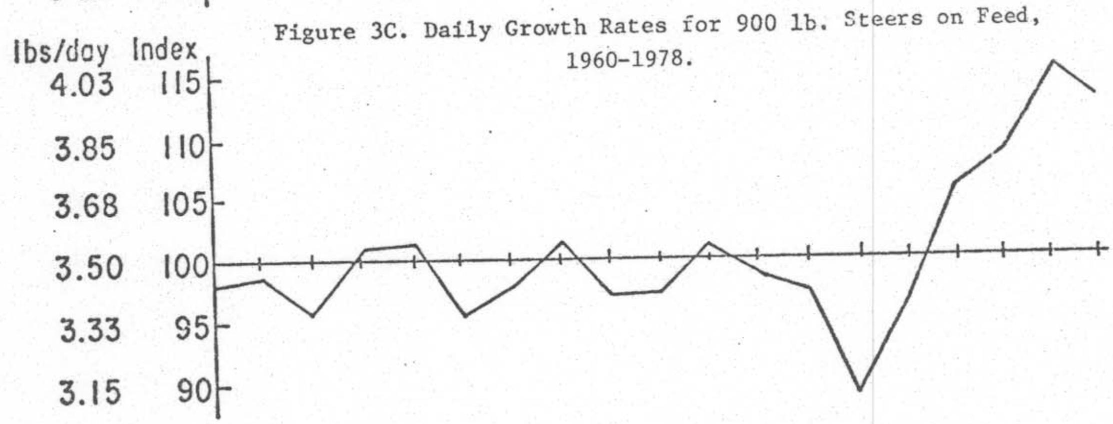

Figure 3C. Daily Growth Rates for 900 lb. Steers on Feed, 1960-1978.

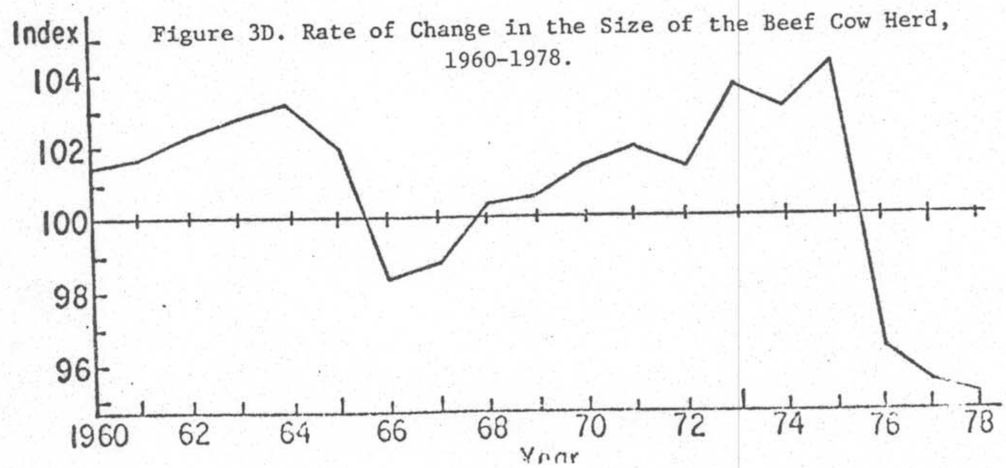

Figure 3D. Rate of Change in the Size of the Beef Cow Herd, 1960-1978.

The index of growth rates, Figure 3C, does not seem to follow the cattle cycle. When regressed against time, it shows a significant positive trend, primarily due to the unprecedented rise in growth rates since 1973. The drop in growth rates observed from 1970 to 1973 may have been due to the legal actions taken against some growth hormones and feed additives. The rapid estimated increases in the growth rates of cattle on feed since 1973 are sustained by observations of animal scientists. They attribute much of this rise to increased cross breeding and the development of alternative legal hormones and feed additives.

Application of the Estimated Data

The data series estimated and reported in the previous section could be applied in the traditional econometric forecasting manner as additional explanatory variables in a regression model. Results of such applications are reported elsewhere (see Trapp, "Forecasting Beef Supplies with Estimated Data," AJAE, August, 1981). Application of the data in an econometric model was shown to improve the accuracy and statistical properties of a traditional short-run econometric beef forecasting model. In addition, the econometric application substantiated the validity of the estimated data by the fact that all the estimated data, when injected into the econometric model, displayed rational signs and parameters with high degrees of statistical significance.

Given historical data series of parameter values that resulted in accurate simulation of fed beef slaughter and inventories, a basis now exists for specifying expected future values of these parameters. Econometric time series methods could be used to describe the seasonal and time trends of the parameters. Alternatively, theoretically based econometric functions could be used to link changes in the parameters to changes in economic factors such as feeder cattle and fat cattle prices, grain prices, etc. Comments of industry laymen about relative changes in the parameters could also be used to adjust estimated values of the parameters based on values found for the previous quarter or a year ago during the same time period. Experience with the model over a two-year period has indicated that an approach using time-series forecasts tempered by subjective adjustments based upon opinions of knowledgeable laymen in the industry results in accurate forecasts.

Forecasting with the Simulation Model

Forecasts of cattle on feed inventories and marketings can be made for one or more quarters by providing the model with the proper physical parameters. The model has been programmed for interactive use on remote terminals. Once accessed, the program queues the user to either enter the required data or accept default values. The default values available are either the value existing for the variable a year ago or time series forecasts of the value. Table 4 lists the queuing statements and a sample set of values. An option is also available which allows the user to view eight quarters of historical

Table 4. Input Data and Queuing Statements of the Cattle on Feed Population Model

(1) Number of cattle placed on feed (1,000 head) - 5795.000
(2) Percentage of cattle placed on feed that will be steers - 61.000
(3) Number of heifers placed on feed - 2264.050
(4) Number of steers placed on feed - 3534.950

Cattle placed on feed

	Month	Number	Percent
(5)	1	2189.0	37.774
(6)	2	2059.3	35.536
(7)	3	1546.7	26.690

(8) Percentage (number) of disappearances - 9.900 (573.705)
(9) Steer slaughter weight - 1186.000
(10) Heifer slaughter weight - 1016.000
(11) Growth index - 1.360

	LB. Range	Percent (or number) of steers
(12)	350-350	5.500
(13)	400-400	5.500
(14)	450-450	5.500
(15)	500-500	14.100
(16)	550-550	14.100
(17)	600-600	14.100
(18)	650-650	14.100
(19)	700-700	7.200
(20)	750-750	7.200
(21)	800-800	7.200
(22)	850-850	7.200

	LB. Range	Percent (or number) of heifers
(23)	300-350	3.100
(24)	350-400	3.100
(25)	400-450	3.100
(26)	450-500	3.100
(27)	500-550	21.900
(28)	550-600	21.900
(29)	600-650	21.900
(30)	650-700	21.900
(31)	700-750	0.0
(32)	750-800	0.0
(33)	800-850	0.0
(34)	850-900	0.0

values for the parameter he has been requested to enter before he actually enters a value.

A total of 34 physical parameter values are required. Entries #1 through #4 describe the number and sex composition of animals placed on feed. Their specification must be based on historical data derived from estimates made using the model. Entries #5 through #7 are used to determine the timing of placements throughout the quarter. In actuality they are the monthly reported seven state cattle on feed placements. The time distribution of these placements is used to allocate the estimated placements specified in entry #1. Entry #8 is for the expected rate of disappearances from the feedlot due to death or removal from feed. This value is reported in the Cattle on Feed Report. Entries #9 and #10 are for expected steer and heifer slaughter weights. Entry #11 is for the estimate of the index of general growth rates. This is a rather critical parameter and one which must be based upon estimates made from the model. It is used to adjust the basic growth rate for each of the seventeen inventory categories. The final 23 entries, i.e., #12 through #34 specify the placement weight distribution of steers and heifers. The placement weight distribution values must also be based upon historical estimates made with the model. As can be noted in the table there are actually only three unique values in the distribution for steers and three for heifers. This is based upon the fact that the estimation process only estimates three categories of placements and assumes a uniform distribution of placement weights within each category. Unique values could be entered into each of the 23 weight ranges specified, but to do so woule be inconsistent with estimated historical data series, and thus, would compromise the objectiveness of the procedure.

In addition to the 34 parameters just discussed the model automatically provides an estimated continuous weight distribution of cattle on feed at the beginning of the quarter to be forecasts, i.e., the 17 inventory categories and the weight distribution of animals within them are defined. This distribution is obtained from the results of the parameter estimation process for the previous quarter. The ending distribution of cattle on feed that was associated with minimization of the forecasting error objective function is retained and used as the beginning inventory distribution. The detail provided in this distribution is of significant importance in forecasting the next quarter's marketings.

Once the user has entered the requested data the model is placed into operation and a forecast generated. Since the model is a continuous dynamic model, daily, weekly or monthly forecasts of marketings and inventories can be generated. Table 5 reports an abbreviated version of the model's output with a two-day interval time period.

Caution should be used in interpreting and using the model's daily, weekly, or even its monthly values. The model was built and "calibrated" to accurately track quarterly data. The daily, weekly,

Table 5. Simulation of Cattle on Feed Data for the Second Quarter of 1981

Period	TOTAL slaughter	Rate of slaughter	Total placed on feed	Rate of placement	TOTAL on feed	Attrition rate
1	119.03	118.81	145.93	145.93	9768.06	16.85
2	237.84	119.39	291.87	145.93	9782.27	12.91
3	257.23	119.55	437.73	145.93	9795.98	12.83
4	476.77	119.40	586.73	145.93	9809.60	12.77
5	596.17	119.02	729.67	145.93	9823.40	12.73
6	715.19	118.45	875.60	145.93	9837.60	12.71
7	833.65	117.73	1021.53	145.93	9852.39	12.70
8	951.37	116.92	1167.47	145.93	9867.90	12.70
9	1068.30	116.18	1313.40	145.93	9901.21	12.70
10	1184.48	115.66	1459.33	145.93	9901.21	12.75
11	1300.14	115.51	1605.26	145.93	9918.67	12.82
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
40	4950.48	140.24	5279.39	103.11	9574.86	12.26
41	5090.72	141.22	5382.50	103.11	9525.57	12.16
42	5231.94	142.06	5485.61	103.11	9475.39	12.06
43	5374.00	142.74	5588.72	103.11	9424.48	11.96
44	5516.75	143.28	5691.83	103.11	9372.99	11.86
45	5660.03	143.68	5794.94	103.11	9321.05	11.77

and monthly data it generates are in essences interpolations between quarterly values. Their accuracy was never considered in the modeling process. However, the intermediate term values generated are not entirely worthless. In many cases, the trend of these intermediate term values can be compared with trends in reported daily slaughter, seven state cattle on feed reports etc. to ascertain whether the patterns occurring during a quarter are consistent with those of the model for a given quarterly forecast. If significant discrepancies are noted between reported short-term data and the intermediate dynamic interpolative output of the model, revisions of the model's quarterly forecast can sometimes be made. These revisions can be accomplished by observing the nature of the discrepancies and altering parameters such as the growth rate, slaughter weight, or placement weight distribution to generate more consistent intermediate values and hence revised quarterly forecasts.

The values in the bottom line of Table 5 for the last period of the quarter can be summarized and augmented to generate a forecast of the complete cattle on feed inventory table as reported by the USDA. Not only can the marketings and total inventory numbers be forecasted, the sex/weight breakdown portion of the table can also be forecasted. Forecasts of the sex/weight distribution table are accomplished by summarizing the information contained in the 17 dynamic distributed delay models. Hence, the final output of the program is a forecasted cattle on feed table of the type shown in Table 6. The only discrepancy of this table versus the one reported

Table 6. Cattle on Feed: Number on Feed, Placed, Marketings, and other Disappearances (April-June, 1980 and 1981)(23 states)

Item		Number 1980	Number 1981	1981 as a percent of 1980
Cattle on feed	April 1	10203	9758	96
Placed on feed	April 1 to June 31	5625	5795	103
Fed cattle marketed	April 1 to June 31	5620	5660	101
Other disappearances	April 1 to June 31	589	572	97
Cattle on feed	July 1	9619	9321	97
Kinds on feed July 1				
Steers, steer calves, and cows		6400	6134	96
Heifers and heifer calves		3273	3187	97
Number on feed by weight group July 1				
Steers and steer calves				
Less than 500 lbs.		227	129	57
500-699 lbs.		915	810	88
700-899 lbs.		2427	1627	67
900-1099 lbs. (including cows)		2241	2565	114
1100 lbs. and over		536	1003	187
Heifers and heifer calves				
Less than 500 lbs.		146	100	68
500-699 lbs.		908	840	93
700-899 lbs.		1619	1455	90
900 and over		600	792	132

by the USDA is that cows are not treated separately, but are considered to be the same as 900-1099 pound steers. Historical values of the categories in the table are stored within the program such that percentage change figures implied by the forecasts can be calculated and printed.

After generating forecasts for one quarter, the user can proceed to forecast another quarter. Such forecasts will be based upon the forecasted values for the first quarter, i.e., the forecasted ending inventory level and weight distribution will be used as the beginning inventory for the next quarter to be forecasted. New parameters will have to be provided for the 34 input parameters, or new default parameters will be used.

A unique feature of the forecasts generated with the simulation model are that the entire set of forecasts made are consistent, i.e., the cattle on feed total inventory number forecasted is completely consistent with the placement, marketings, and sex/weight distribution forecasts generated. This is not the case with most econometric models. Additionally, the entire set of forecasts were made based upon physical parameters. This is a significant advantage in explaining the assumptions of the forecasts made to industry laymen.

Forecasting Accuracy of the Model

Two tests of the model's forecasting accuracy will be reported here. The first test uses an objective method of providing input parameters for the simulation model and compares the model's simulation forecasts to forecasts made with an econometric model. For the second test, actual forecasts generated by using the model in a subjective manner over the past five quarters are compared with a group of cattle on feed report forecasts made by 17 commercial commodity forecasters.

For the first test of the model's forecasting accuracy an objective method of providing values of the input parameters for the simulation process was required. Simple first order autocorrelation models of the following form were used to forecast the values of the input parameters required:

$$Y_t = a + bY_{t-1} + cD_2 + dD_3 + eD_4$$

where Y_t is the dependent variable, i.e., input parameter value sought, Y_{t-1} is the dependent variable lagged one quarter, and D_2, D_3 and D_4 are seasonal dummy variables for the second, third and fourth quarters, respectively. While simple in nature, the average R^2 value of the above equation form was approximately .70 for the set of equations estimated. Thus, considerable first order autocorrelation existed in the time series of the input parameter values. Results of the simulation model's forecasts of fed beef marketings using the input parameter values forecasted with time series equations were compared to forecasts of fed beef marketings made with the following traditional econometric model:

Marketings = a + b(# of heifers on feed over 700 lbs.) + c (# of steers on feed over 900 lbs.)

+ seasonal dummies

Results of each model's forecasts are reported in Table 7. The accuracy of the two models is quite similar; however, the simulation model's accuracy is slightly better. Undoubtedly, the forecasting accuracy of the input parameter values, and hence, the simulation model's accuracy could be improved upon. However, much of the simulation model's accuracy is embodied within the inventory weight distribution data stored in the model as generated by optimizing the model's forecasting objective function for the previous quarter. These values, plus input parameters for the growth rate and slaughter weight are critical to the models accuracy in forecasting marketings.

The second evaluation of the model's forecasting ability is of a different nature. The model has been used by the author for five quarters to make forecasts of the cattle on feed report approximately one week before the report's release date. The model's forecasts have been reported to the Commodity News Service and printed over the wire along with the forecasts of 23 other commercial commodity firms. The model was applied in a subjective manner to make

Table 7. Comparisons of Ex post Forecasts of the Simulation Model and a Traditional Econometric Model

Year-quarter	Reported number of cattle on feed marketed	Traditional econometric model	Simulation model
1977-1	6,462	6,954	6,030
1977-2	6,147	6,493	6,303
1977-3	6,159	6,505	5,481
1977-4	6,093	6,111	6,073
1978-1	6,773	6,996	7,185
1978-2	6,591	7,200	6,670
1978-3	6,536	7,110	5,910
1978-4	6,730	7,257	6,715
Root - Mean - Squared - Error			
Mean Absolute error			
Thiel's inequality coefficient			

these forecasts. Actually, forecasting the USDA cattle on feed report one week before its release is not forecasting at all, rather it is describing what has already happened but has not yet been reported. The only forecasting done is that of forecasting the USDA's data. In this endeavor the model's dynamic interpolative properties and physical basis prove useful in making subjective adjustments. The set of input parameters objectively determined at the beginning of the quarter can be adjusted by several means, i.e., the dynamic interpolative paths of the model's projections can be compared to reported data such as the seven state cattle on feed inventory and marketings numbers and/or federally inspected slaughter numbers; comments of industry layman regarding growth rates and placement weights can be incorporated; slaughter weights during the quarter can be deduced accurately from data available which covers most of the quarter. While a degree of subjective judgment is involved in adjusting the original objectively defined parameters in response to the above type considerations, the model provides the basis for forming and evaluating the judgments made. The subjective judgments involved are such that most individuals would likely make similar adjustments given the same information. A great deal of experience and/or training is not required to make successful subjective modifications to the input parameters via the process described.

The accuracy of the author in using the model to forecast the 23-state quarterly cattle on feed report in the above described subjective manner has been compared with the accuracy of 17 other forecasters. The results of these comparisons are reported in Table 8. All of the forecasters listed in Table 8 submitted forecasts to the Commodity News Service of cattle on feed inventories, marketing, and placements over the five quarters considered. Six other forecasters submitted forecasts to the wire service during this period but did not submit forecasts for all five quarters; hence, they are not considered in the comparisons reported in Table 8. In each of the three forecasting categories, i.e., cattle on feed, marketings, and

Table 8. Comparison of Subjective Simulation Model Forecasts of the Quarterly Cattle on Feed Report with Commercial Forecasters Forecasts[a]

Forecasters	Type of Forecast						Overall	
	Cattle on feed		Marketing		Placements			
	Rank	Avg. % error	Rank	Avg. % error	Rank	Avg. % error	Rank	Avg. % error
ACLI International	9	1.88	18	2.74	14	3.52	15	2.71
Cargil Investors	16	2.50	3	1.40	11	3.10	11	2.33
Conticommodity	7	1.75	16	2.25	17	4.25	16	2.75
Data Resources Inc.	15	2.30	1	2.28	16	3.70	17	2.76
Dean Witter	11	2.10	14	2.20	9	2.90	13	2.40
Drexel Burnham	10	2.00	9	1.80	3	2.40	4	2.07
Farmers Grain	18	2.60	3	1.40	6	2.60	9	2.20
Heinold Commodity	16	2.50	5	1.50	15	3.60	14	2.53
Lawless Commodity	8	1.80	14	2.20	2	2.20	4	2.07
Lind-Waldock	4	1.60	9	1.80	10	3.00	6	2.13
LBAS	13	2.20	7	1.60	12	3.20	11	2.33
Merrill Lynch	1	1.40	12	2.00	18	5.20	18	2.87
Professional Cattle Cons.	6	1.74	2	1.26	5	2.56	2	1.85
Shearson Loeb Rhoades	11	2.10	9	1.80	4	2.50	6	2.13
Texas Ag. Res. Assoc.	3	1.48	8	1.72	7	2.68	3	1.96
Thomson McKinnon	14	2.22	5	1.50	13	3.24	10	2.32
Western Livestock Assoc.	5	1.70	12	2.00	8	2.80	8	2.17
James Trapp, O.S.U.	1	1.40	1	1.00	1	2.00	1	1.47

[a]Forecast comparisons made were for five consecutive quarters beginning with the second quarter of 1980.

placements, the forecasts made with the simulation model are, on the average, superior to those made by the other 17 forecasters.

Another standard for analyzing the accuracy and usefulness of the simulation model as a subjective forecasting tool of the quarterly cattle on feed report is to compare it's accuracy to an econometric model designed for the same purpose. Such a model has recently been developed by John Franzmann and reported in the Oklahoma Current Farm Economics bulletin. Franzmann's econometric model consists of three equations which predict 23 state quarterly cattle on feed inventories, marketings, and placements. The equations regress reported monthly seven state inventories, marketings, and placements for the first two months of the quarter upon the 23 state quarterly report values desired. The accuracy of Franzmann's model in terms of average percentage error for the same five quarters reported in Table 8 was: Cattle on Feed, 1.42%; Marketings, 0.80%; Placements, 3.92%; and Overall Average Percentage Error, 2.05%. In relation to the forecasts evaluated in Table 8, the overall rank of Franzmann's model would have been fourth. Franzmann's marketings forecast accuracy was superior to that of any of the forecasts reported in the table, including the simulation model based forecasts. Hence, the subjective use of the simulation model versus Franzmann's econometric model resulted in slightly better overall forecasts. However, it should be noted that the simulation model is more complex to apply and Franzmann's model is totally objective.

Summary

A methodology for forecasting fed beef supplies with an aggregate fed beef population simulation model has been presented. It is contended that the methodology provides a rigorous and objective method of incorporating unreported information about the physical nature and performance of feedlot animals into the fed beef supply forecasting process. In so doing, the model provides a tool for improving fed beef supply forecasting accuracy and for explaining and understanding the fed beef inventory situation.

The methodology developed for using a simulation model to forecast fed beef supplies was compared with several econometric approaches to forecasting fed beef supplies and found, in each case, to be more accurate. In addition to being more accurate, it is contended that the simulation approach is more intuitively appealing to laymen; and therefore, more prone to be readily accepted and used by them. It is based upon a set of physical parameters and logic that are more familiar to them than the attributes and logic of econometric models.

The methodology developed is perceived to be new and significantly different. It provides an alternative approach to livestock supply forecasting. While the methodology and results presented here appear useful in their own regard, it is hoped that potential exists for future development and refinement of the methodology. Most of the potential for supply forecasting with econometric methods would appear to have already been achieved. A potentially fruitful area of use of the methodology developed is in estimating unknown pieces of information about non-fed beef populations and proceeding to develop a similar non-fed beef supply model. The pork supply complex could also be modeled in a manner similar to the fed beef model presented here.

Footnotes

[1]It is assumed that no steers weighing less than 350 pounds or more than 899 pounds and no heifers weighing less than 300 pounds or more than 899 pounds are placed on feed.

[2]The distinct discontinuities observed in the 400 and 500 pound beginning weight curves are due to assumed ration changes which disrupt feeding and growth patterns for brief intervals.

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