PREDICTIVE MODELS FOR SOUTHERN
STATE CATTLE INVENTORIES

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As noted in a recent article by Harris [5], many agricultural economics departments in recent years have expanded their commitments to providing market outlook information. Continuing volatile commodity prices will provide an ongoing demand for such information.

This paper presents results of a study designed to provide short term predictions of the number of cattle and calves on farms, January 1, in each of twelve southern states.[1] Such estimates can help outlook personnel in several ways, including providing indications as to how producers are reacting to recent market conditions in each of these states and the region. The models do not require demand estimates for beef, nor are results likely to prove as self-defeating as price predictions might if publicized. Form of the models was suggested by work on an earlier national cattle marketing model [6].

Coincidentally, these models meet some of the criticisms of out-look programs offered by Harris [5]. Development of the models involved extensive use of quantitative techniques, including both ordinary and nonlinear least squares. They are relatively simple models of partial systems. In addition, results presented here suggest potentially fruitful revisions of specific state models and possible eventual development of a regional model.

CHOICE OF PREDICTIVE VARIABLES

For predictive models to be useful, required input data must be available several months in advance of publication of Statistical Reporting Service estimates of the number of cattle and calves

on farms January 1 by state (early February). The prediction period desired for these models was one year.

The inventory of cattle and calves is necessarily a function of past inventories. Hence, the January 1 inventory, lagged one year, is included in the models as an independent variable. Two and three year lags were also tried with this variable, but their use resulted in equations having lower coefficients of determination.

Initially, two deflated monthly (April and September) calf prices were included in the model as measures of the state of the cattle market and returns to producers. Monthly prices were chosen over lagged annual averages primarily because of timeliness. Monthly price estimates are available by state shortly after the end of the month to which they apply. Annual averages are not available until several months after the end of the year to which they apply.

Calf prices were chosen because southern beef producers have historically depended on feeder calves for the bulk of their revenue, particularly over the last twenty years. April and September prices were chosen because these months are near the beginning and end of the summer grazing season. The April price occurs near the end of winter-grazing and the beginning of weaning of fall calves.

Prices were deflated using the Index of Prices Paid for Production Items by Farmers adjusted to a 1975 base. Initial analyses used both this index and April and September fertilizer price estimates (also reported by the Statistical Reporting Service) as both deflators and independent variables. The data base for fertilizer prices (on a state basis) was, however, much

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[1] The states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia. These were selected primarily because of a shared need for relatively heavy nitrogen fertilization for maintenance of carrying capacity of pastures.

smaller than that for the index. Better fitting equations were obtained using the Index of Prices Paid as a deflator rather than as an independent variable.

Table 1 presents the average price received for calves by farmers in April for the years 1949-76, in both current and deflated (1975) dollars in Georgia, as well as the number of cattle and calves on farms January 1. Note that, with the exception of the period around 1960, peaks in cattle and calf numbers occur approximately one to two years after peaks in prices.

Efforts to include both the April and September calf prices in the model invariably resulted in obtaining a negative coefficient for one of the price variables, regardless of the lag or combination of lags (1 year or 2 years) used. In an effort to detect possible autocorrelation and to estimate a logically acceptable model using both prices, two nonlinear least squares procedures were applied to a model including the September price lagged two years and the April price lagged one year. One procedure was

TABLE 1. AVERAGE PRICES RECEIVED FOR CALVES BY FARMERS IN APRIL, IN CURRENT AND DEFLATED DOLLARS, AND NUMBER OF CATTLE AND CALVES ON FARMS JANUARY 1, GEORGIA, 1949-76[a]

	Average prices received for calves, April		
Year	Current dollars	1975 dollars	Cattle and calves on farms, 1-1
	- - per hundredweight - -		1,000 head
1949	21.40	46.69	982
1950	22.00	48.40	1,040
1951	31.00	59.30	1,113
1952	28.50	53.55	1,247
1953	17.20	35.20	1,422
1954	16.00	32.74	1,564
1955	15.70	32.38	1,627
1956	16.20	34.35	1,546
1957	16.80	34.25	1,515
1958	23.10	46.03	1,485
1959	27.80	54.57	1,515
1960	23.00	45.31	1,424
1961	22.20	43.90	1,438
1962	23.80	46.54	1,481
1963	23.50	45.45	1,496
1964	20.50	39.79	1,571
1965	19.30	36.92	1,852
1966	24.40	45.52	1,815
1967	24.20	44.52	1,797
1968	25.50	46.11	1,833
1969	30.50	53.15	1,870
1970	35.00	59.04	1,889
1971	33.00	52.96	2,002
1972	40.00	61.75	2,042
1973	57.30	75.83	2,062
1974	46.20	50.93	2,103
1975	24.00	24.18	2,420
1976	32.90	30.96	2,370

[a]Sources of data are a variety of USDA publications including Statistical Bulletins 177, 265, 278, 294, 319, and succeeding issues of *Agricultural Prices, Livestock and Poultry Inventory, Livestock and Meat Statistics* and *Cattle.*

developed by Fuller and Martin [3] based on the general model of Hartley [6]. The other was developed by Fuller [4]. Only one of the (24) models estimated an autocorrelation coefficient significant at the 10 percent probability level. And the signs were still logically inconsistent.

Though the variance inflation factors were acceptably low (3 to 4) in the ordinary least squares models, as compared to Snee's recommendation of 4 to 5 [10], the basic problem was multicollinearity. This was still a problem even when one of the two prices in the model was transformed as noted in the next paragraph. Thus, only one price and the lagged dependent variable are retained in the final models.

Two forms of the deflated price variable were used in selecting models presented herein. One form was simply the deflated monthly average price received by farmers for calves. The second form was obtained by subtracting the mean of the deflated price (simple average over the years 1949-75)[2] from the deflated monthly average (April or September) for each year and dividing resulting differences into two variables: one being the positive differences (zero value otherwise), the other the negative differences (zero value otherwise). Two hypotheses form the basis for this transformation: (1) the mean price is *an* estimate of all costs of production of calves, including returns to producers' capital and risk-taking but excluding "profit", as defined by Knight [8], and (2) positive deviations of price from costs of production will have effects which differ in both sign and absolute magnitude from effects of negative deviations. Use of this transformation was prompted in part by Crowder's conclusion [1] that a profit index is more useful in predicting cow slaughter than is price per se. However, Crowder's profit index is apparently based on subtraction of budget costs from prices.

THE STATE MODELS AND RESULTS

The models finally chosen for prediction of January 1 state cattle and calf inventories in the South are presented in Table 2. These models use as independent variables the dependent variable lagged one year and one monthly (April) calf price lagged two years. Calf price, rather than deviations from a mean price, is used because models using the two alternative forms of monthly calf price produced approximately equal coefficients of determination and simplicity was used as a model selection criterion.

[2]These simple averages rounded to the nearest half dollar, per hundredweight, are as follows by state for April: $46.00 (Alabama), $49.50 (Arkansas), $45.50 (Florida), $46.50 (Georgia), $54.50 (Kentucky), $47.00 (Louisiana), $46.00 (Mississippi), $52.00 (North Carolina), $48.50 (South Carolina), $50.50 (Tennessee), $55.50 (Virginia), $55.00 (West Virginia).

TABLE 2. MULTIPLE REGRESSION EQUATIONS FOR PREDICTION OF NUMBER OF CATTLE AND CALVES ON FARMS, (THOUSAND HEAD), JANUARY 1, FOR EACH OF TWELVE SOUTHERN STATES, TWENTY-SIX OBSERVATIONS[a]

State	Intercept	Partial regression coefficent for[b] AP_{t-2}	C_{t-1}	Coefficient of determination	Durbin h-statistic
Alabama	98.164	6.498 (3.99)	.801 (11.14)	.876	.433
Arkansas	-149.781	6.118 (4.23)	.930 (15.23)	.933	.191
Florida	72.313	5.069 (2.304)	.860 (7.91)	.824	.669
Georgia	- 4.374	4.707 (2.69)	.896 (16.37)	.933	.432
Kentucky	-111.156	2.650 (1.21)	1.016 (29.63)	.978	- .080
Louisiana	308.022	3.490 (1.64)	.745 (6.74)	.713	2.202
Mississippi	401.854	2.539 (.92)	.787 (8.03)	.764	.755
North Carolina	228.793	1.811 (1.45)	.674 (6.75)	.702	.633
South Carolina	106.513	1.269 (1.60)	.733 (9.35)	.806	.923
Tennessee	-149.230	4.717 (4.19)	.980 (31.56)	.983	.962
Virginia	91.460	3.146 (3.33)	.821 (10.54)	.858	.0809
West Virginia	- 79.140	1.426 (4.11)	.998 (18.96)	.945	1.177

[a]Sources of input data are a variety of USDA publications including Statistical Bulletins 177, 265, 278, 294, 319 and succeeding issues of *Agricultural Prices, Livestock and Poultry Inventory, Livestock and Meat Statistics* and *Cattle.*

[b]AP_{t-2} = Average price received by farmers for calves in April, lagged 2 years and deflated using the April Index of Prices Paid for Production Items by Farmers (1975 base).

C_{t-1} = Number of cattle and calves on farms, lagged 1 year, in thousands of head.

Numbers in parentheses are t-values of partial regression coefficients above. Twenty-four years (1951-74) were included in the sample.

Form of the models is as follows:

$$C_t = a + b_1 \, AP_{t-2} + b_2 \, C_{t-1}$$

where

C_t = number (in 1,000 head) of cattle and calves on farms January 1 in year t;

AP_{t-2} = deflated (1975 base year) average price received for calves by farmers.

Anticipating the possibility of autocorrelated errors affecting estimation of the model, the Durbin h-statistic, developed by Durbin [2] specifically to test for autocorrelation in models incorporating lagged dependent variables as independent variables, was computed. Usefulness of this statistic for small sample work has been confirmed by Park [9]. In one case, the h-statistic is significant at the five percent probability level, though it is not significant even at the ten percent level for any other state.

Results in Table 2 can be interpreted to mean that these models are acceptable for most of the twelve states. But they also indicate that additional work, perhaps relating cattle numbers to prices and/or acreages of one or more crops, is desirable,

particularly for Louisiana, Mississippi, North Carolina and South Carolina.

Table 3 presents regional totals for the twelve states of actual and predicted values of the number of cattle and calves on farms January 1 for the years 1951-1977. Note that the simple coefficient of determination for these actual and predicted values, sums though they be, is higher than any multiple coefficient of determination for any one state model. Sums of the predicted state inventories are apparently more reliable estimates of sums of actual inventories than any individual state prediction is of any actual individual state inventory. This suggests development of a regional model based on use of dummy variables; however, introduction of such variables into the model also introduces multicollinearity.

CONCLUSIONS

Meaningful predictive models for southern state cattle and calf inventories have been developed relating the inventory to that of the most recent past year, and to the deflated average price received for calves for farmers in April lagged two years. The price lag probably arises from the length of time required between a decision to keep a heifer for breeding and arrival of her first calf plus the "cobweb" behavior of calf producers, i.e., basing price expectations on current prices. In addition, this lag may be accen-

TABLE 3. ACTUAL AND PREDICTED NUMBER OF CATTLE AND CALVES ON FARMS, JANUARY 1, IN TWELVE SOUTHERN STATES WITH ANNUAL PERCENTAGE CHANGES IN EACH AND PERCENTAGE DEVIATIONS OF PREDICTED FROM ACTUAL, 1951-77

Year	Number of cattle and calves on farms[a] Actual, 1/1	Change	Predicted, 1/1	Change	Deviation of predicted from actual
	1,000 head	%	1,000 head	%	%
1951	14,256		14,463		1.5
1952	15,520	8.9	15,336	6.0	-1.2
1953	17,379	12.0	16,895	10.2	-2.8
1954	18,321	5.4	18,186	7.6	-0.7
1955	18,178	- 0.8	18,223	0.2	0.2
1956	18,051	- 0.7	17,914	- 1.7	-0.8
1957	18,131	0.4	17,788	- 0.7	-1.9
1958	17,550	- 3.2	17,919	0.7	2.1
1959	17,963	2.4	17,483	- 2.4	-2.7
1960	17,244	- 4.0	18,224	4.2	5.7
1961	17,415	1.0	18,091	- 0.7	3.9
1962	17,745	1.9	17,913	- 1.0	0.9
1963	18,033	1.6	18,128	1.2	0.5
1964	18,635	3.3	18,502	2.1	-0.7
1965	19,897	6.8	19,025	2.8	-4.4
1966	19,651	- 1.2	19,894	4.6	1.2
1967	19,631	- 0.1	19,555	- 1.7	-0.4
1968	19,967	1.7	19,968	2.1	0.0
1969	19,995	0.1	20,215	1.2	1.1
1970	20,407	2.1	20,355	0.7	-0.3
1971	20,515	0.5	20,914	2.7	1.9
1972	21,234	3.5	21,313	1.9	0.4
1973	21,927	3.3	21,728	1.9	-0.9
1974	23,090	5.3	22,699	4.5	-1.7
1975	26,752	15.9	24,248	6.8	-9.4
1976	25,738	-3.8	26,417	8.9	2.6
1977	24,629	-4.3	24,342	- 7.9	-1.1

[a]Simple coefficient of determination between the actual and predicted values for the sample period 1951-74 is .960.

tuated by a tendency toward optimism even in the face of a price decline.

Results of application of these models can not only be used for prediction of individual state inventories but also, when summed, for prediction of a regional inventory.

Results presented imply that further development of the models is desirable, particularly for certain states. Possibly incorporation of variables such as prices received for selected crops or acreages of selected row crops would improve the models. Soy-bean prices and acreages might be especially important predictor variables for some states.

Separation of the total inventory into the breeding cow herd and other components may also be fruitful for predictive purposes, particularly if southern cattlemen do indeed place more emphasis on production and sale of heavier cattle, as opposed to feeder calves, in the future. The change which occurred in USDA classifications within the herd (from an age-based to a weight-based classification) will probably impede development of such models, however.

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