Predicting the Beef Cattle Inventory

By Forrest Walters

THE NUMBER of beef cattle which beef producers plan to keep on farms is due largely to the prices they expect to receive for feeder calves or slaughter animals. In this paper simple relationships between cattle numbers and past prices are constructed to embody the latest price information available for estimating beef cattle numbers from 6 months to more than a year in advance.[1] The relationships have been deliberately kept simple so that they can be used conveniently. In addition to prices used in these relationships, many other events must be examined by the forecaster to see whether they will influence the decision to keep more or fewer cattle on farms.

The Beef Inventory Cycle

The beef cattle industry in the past has been subject to costly cyclical movements. The industry seems to be seized periodically with "spontaneous optimism." During these periods, usually following favorable prices, the growth rate of cattle numbers exceeds an equilibrium growth rate. Cattle numbers in the optimistic periods are increased by adding cows to the basic breeding herds and by keeping feeder cattle longer than usual, consequently to heavier weights. This increasing production finally exceeds the increasing demand, causing first slaughter prices and then feeder prices to decrease.

With the advent of lower prices the industry becomes subject to a kind of "simultaneous pessimism." The pessimistic cattle producers then reduce the size of their basic breeding herds (because they are less profitable) by selling cows from these herds for slaughter and not replacing them with heifers. This adds even more to total production and further lowers slaughter prices. Feeders retain the cattle that they are feeding in hopes of better prices. However, after it becomes apparent that prices have stabilized at the lower levels the fed-cattle producers must then sell their cattle at heavier weights than usual. These cattle are heavier because they have been retained for a longer time on a concentrate ration. Again this adds to the already towering production.

The cattle industry has been subject to three separate cycles since 1929. Each successive cycle has required a shorter liquidation period. The cycle which began with 1929 took 6 years to build up the inventory. After 1934 it required 5 years to deplete this inventory and begin a new cycle in 1940. The new cycle took 6 years for the inventory to build up to such a position that it was necessary to liquidate. The liquidation period which began with 1946 required only 3 years. The most recent cycle which we can observe began with 1949 and took 8 years to accumulate an inventory that depressed prices and resulted in liquidation. However, the liquidation phase lasted only 2 years. We are on our sixth year of accumulation in the present cycle which began with 1959. Will we continue to adjust or to liquidate over short periods of time, or can herds continue to increase over a long period of time without a destructive liquidation phase of the cycle occurring? These cycles can be observed in figure 1.

Classes of the Inventory

The inventory of beef cattle is divided into four classes: cows and heifers 2 years and older; heifers 1 to 2 years old and steers 1 year and older; calves and bulls 1 year and older. This inventory, often called "other" cattle, is shown in table 1. The total beef cattle inventory is, of course, the summation of each of these segments of the inventory.

This study uses separate relations to estimate each class of the inventory 6 and 12 months in

[1]The author is grateful to Anthony S. Rojko of ERS for helping with the forecasts made more than a year in advance, and to R. L. Rizek, Don Seaborg, and George R. Rockwell, Jr., for their suggestions and for making data available.

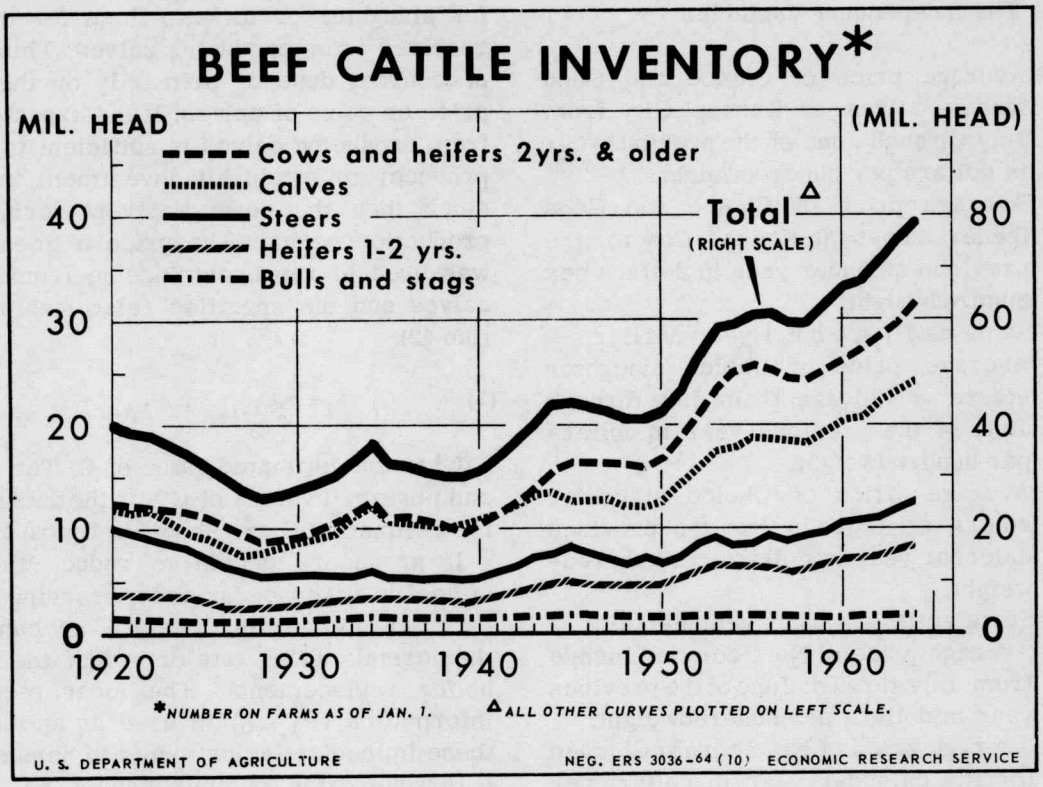


Figure 1

Table 1.--Beef cattle and calves on farms, January 1, 1947-64

Year	Heifers 1-2 years old and steers 1 year and older	Calves	Bulls 1 year and older	Cows and heifers 2 years and older	Total
	1,000 head	*1,000 head*	*1,000 head*	*1,000 head*	*1,000 head*
1947..	11,745	12,804	1,834	16,488	42,871
1948..	11,190	12,046	1,756	16,010	41,002
1949..	11,927	12,033	1,681	15,919	41,560
1950..	11,559	12,516	1,690	16,743	42,508
1951..	12,151	14,319	1,689	18,526	46,685
1952..	14,371	15,829	1,774	20,863	52,837
1953..	15,682	17,440	1,907	23,291	58,320
1954..	14,594	17,978	1,896	25,050	59,518
1955..	14,958	18,804	1,829	25,659	61,250
1956..	15,689	18,869	1,762	25,371	61,691
1957..	14,017	18,405	1,713	24,534	59,569
1958..	15,155	18,275	1,619	24,165	59,214
1959..	16,488	19,407	1,607	25,112	62,614
1960..	17,610	20,425	1,676	26,344	66,055
1961..	18,046	20,705	1,707	27,102	67,560
1962..	18,393	22,050	1,704	28,305	70,452
1963..	20,038	23,330	1,747	29,970	75,085
1964..	20,826	24,417	1,812	31,779	78,834

Source: Listed as "Other Cattle & Calves" in Livestock and Meat Statistics, U.S. Dept. Agr., Statis. Bul. 333, p. 4, July 1963.

advance. These individual estimates are then combined to form an estimate of the total inventory. Simple relationships between prices of slaughter cattle, prices of feeder cattle, and cattle numbers are used to make these estimates, recognizing that more complex relationships could have been established. The variables used in these relations are as follows:

The Dependent Variables

I_t = Total number of beef (other) cattle on farms January 1, in millions of head.

C_t = Total number of beef cows and heifers 2 years and older on farms January 1, in millions of head.

V_t = Total number of beef calves on farms January 1, in millions of head.

B_t = Total number of beef bulls 1 year and older on farms January 1, in millions of head.

Y_t = Total beef heifers 1 to 2 years old and beef steers 1 year and older, in millions of head.

The Independent Variables

$P_{1,t-6}$ = Average price of Choice and Good feeder calves at Kansas City from July through June of the previous year in dollars per hundredweight.

$P_{1,t-12}$ = Average price of Choice and Good feeder calves at Kansas City for the previous calendar year in dollars per hundredweight.

$P_{1,t-18}$ = Same as $P_{1,t-6}$ but 1 year earlier.

$P_{2,t-6}$ = Average price of Choice slaughter steers at Chicago from July through June of the previous year in dollars per hundredweight.

$P_{2,t-12}$ = Average price of Choice slaughter steers at Chicago for the previous calendar year in dollars per hundredweight.

$P_{2,t-18}$ = Same as $P_{2,t-6}$ but 1 year earlier.

$P_{3,t-6}$ = Average price of No. 2 corn at Chicago from July through June of the previous year in dollars per hundredweight.

$P_{3,t-12}$ = Average price of No. 2 corn at Chicago for the calendar year in dollars per hundredweight.

$P_{3,t-18}$ = Same as $P_{3,t-6}$ but 1 year earlier.

C_{t-12} = Total number of beef cows and heifers 2 years and older on farms January 1, the previous year, in millions of head.

V_{t-12} = Total number of beef calves on farms January 1, the previous year, in millions of head.

Five equations are used to show the relationship between the unknowns and the independent variables. The five unknowns are linked in inventory equation (1).

$$(1) \qquad I_t = C_t + V_t + B_t + Y_t$$

THE COW INVENTORY

Income from beef cows can be derived from two sources. The cows may be sold for slaughter to produce an immediate income or they may be kept in the breeding herds to produce calves. Income to this investment in calf production is measured by the value of the calves. Each year the beef calf producer must decide whether to receive the immediate income from selling cows for slaughter or to keep them for the income received from producing calves. This decision, of course, depends primarily on the expected price or value of calves. If the expected income from producing calves is sufficient to induce the producer to retain his investment in breeding stock then the cows are kept during another production period. The price of feeder calves was used to represent income from producing calves and the specified relationship is equation (2).

$$(2) \qquad C'_t = a_1 + b_1 C_{t-12} + b_2 P_{1,t-6} + b_3 P_{1,t-18}$$

C' is the estimated value of C. The estimated and observed values of C with the data necessary for estimating C are shown in figure 2.

If producers decide to reduce the number of beef cows kept on farms for breeding purposes, they can do so immediately. They can increase the normal culling rate or reduce the number of heifer replacements. The most recent price information ($P_{1,t-6}$) is used as an indicator of these immediate adjustments in herd size.

However, the number cannot be increased without planning and without a time lapse beforehand. Although the beef cow herd can be increased somewhat by adding 2-year-old heifers and reducing the culling rate, the usual practice is to keep 6-month-old heifer calves rather than selling them to feedlots. It is fully 18 months before these heifer calves can be included in the numbers of beef cows 2 years and older. This increase in calves is not reflected in the cow inventory, C_{t-1}. For this reason, if current prices are expected prices, the price $P_{1,t-18}$ must be used to explain increases in C_t.

One of the undesirable features of equation (2) is that it provides estimates only 6 months in advance. Of more interest would be an equation which would give estimates of an event at least a year in advance. One such relationship could be equation (2) with $P_{1,t-6}$ removed. For example:

$$(3) \qquad C'_t = a_2 + b_4 C'_{t-12} + b_5 P_{1,t-18}$$

where C'_{t-12} would be estimated by equation (2). Another alternative would be

$$(4) \qquad C'_t = a_2 + b_4 C'_{t-12} + b_5 P_{1,t-12}$$

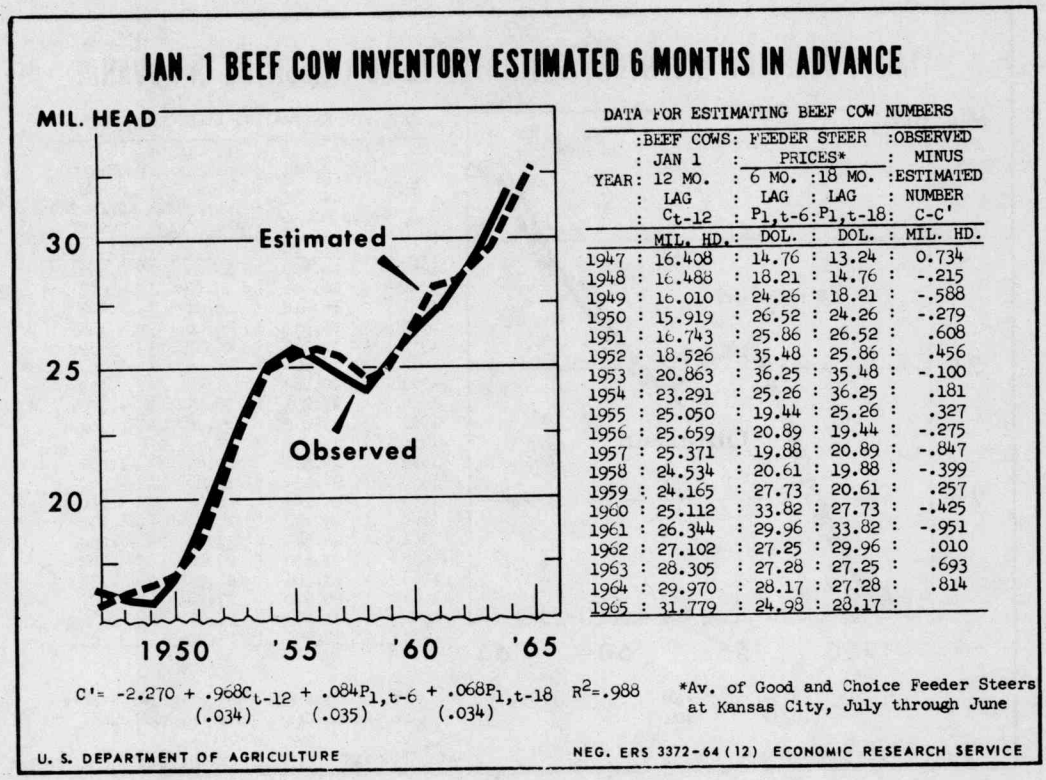


Figure 2

Use of equation (4) would require a partial forecast of the price variable if the forecast is made before data for the calendar year are available.

The conditional forecast for beef cow numbers on January 1, 1965, using equation (2) is 32.5 million head (see fig. 2). The forecasts for 1966 are 32.9 million head using equation (3) and 32.7 million using equation (4). Figures 3 and 4 illustrate forecasts made from this equation.

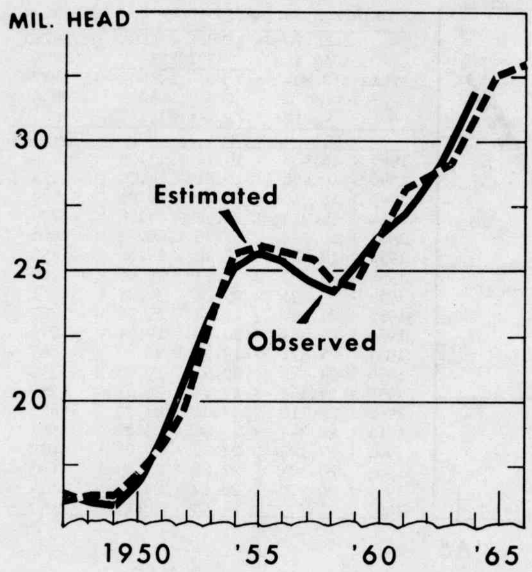
There are many other events or factors besides price of feeder calves which should be watched closely between the time that these estimates of cow numbers are made and the time that the cow numbers are observed; for example, the ecological balance of plant and animal life in the range areas. This balance certainly has an effect on the numbers of cows producers are able to keep on pastures or ranges for breeding purpose. Western range and cattle conditions in 1963 and to date in 1964 have not been as good as they were from 1958 through 1962. When range conditions have been bad for several years, the cost of feeding cows through the winter increases because of the additional roughage needed.

In addition, the most recent prices of feeder calves should be observed. For example, the average feeder calf price of $24.98 from July 1963 through June 1964 declined to an average of $21.58 in July, August, and September.

THE CALF INVENTORY

The calf inventory as of January 1 cannot exceed the number of calves born during the preceding year. The number of calves born during the year depends on the fertility rate (number of calves born per 100 cows). This rate has remained at 86 calves per 100 cows since 1958. The number of these calves that remain on farms January 1 the following year has also remained rather stable at around 77 calves per 100 cows since 1958. This, of course, may fluctuate occasionally depending on when most of the calves are born during the year and the number of dairy calves kept for feeding purposes. The stable relationship between beef

JAN. 1 BEEF COW INVENTORY ESTIMATED 12 TO 18 MONTHS IN ADVANCE



$C' = -1.203 + .953C_{t-12} + .126P_{1,t-18}$ $R^2 = .983$
(.038) (.027)

DATA FOR ESTIMATING BEEF COW NUMBERS

YEAR	C_{t-12} BEEF COWS JANUARY 1 12 MO. LAG	$P_{1,t-18}$ FEEDER STEER PRICES* 18 MO. LAG	C-C' OBSERVED MINUS ESTIMATED NUMBER
	MIL. HD.	DOL.	MIL. HD.
1947	16.408	13.24	0.393
1948	16.488	14.76	-.353
1949	16.010	18.21	-.423
1950	15.919	24.26	-.274
1951	16.743	26.52	.439
1952	18.526	25.86	1.161
1953	20.863	35.48	.151
1954	23.291	36.25	-.500
1955	25.050	25.26	-.182
1956	25.659	19.44	-.317
1957	25.371	20.89	-1.062
1958	24.534	19.88	-.507
1959	24.165	20.61	.700
1960	25.112	27.73	.133
1961	26.344	33.82	-1.050
1962	27.102	29.96	-.083
1963	28.305	27.25	.778
1964	29.970	27.28	.997
1965	31.779	28.17	
1966	32.509	24.98	

*Av. of Good and Choice Feeder Steers at Kansas City, July through June

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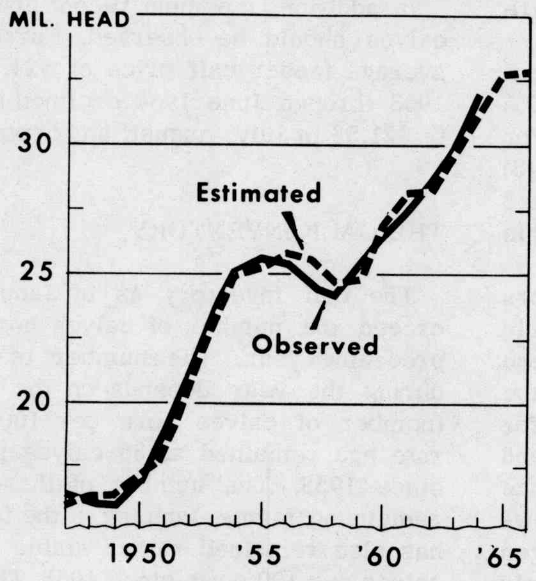
Figure 3

JAN. 1 BEEF COW INVENTORY ESTIMATED 12 MONTHS IN ADVANCE



$C' = -1.863 + .972C_{t-12} + .132P_{1,t-12}$ $R^2 = .985$
(.035) (.026)

DATA FOR ESTIMATING BEEF COW NUMBERS

YEAR	C_{t-12} BEEF COWS JANUARY 1 12 MO. LAG	$P_{1,t-12}$ FEEDER STEER PRICES* 12 MO. LAG	C-C' OBSERVED MINUS ESTIMATED NUMBER
	MIL. HD.	DOL.	MIL. HD.
1947	16.408	13.94	0.553
1948	16.488	16.11	-.290
1949	16.010	20.78	-.534
1950	15.919	27.21	-.472
1951	16.743	24.81	.828
1952	18.526	29.99	.746
1953	20.863	37.86	-.139
1954	23.291	31.58	.090
1955	25.050	20.55	.448
1956	25.659	20.21	-.388
1957	25.371	21.04	-1.054
1958	24.534	19.57	-.415
1959	24.165	23.36	.389
1960	25.112	31.68	-.400
1961	26.344	32.65	-.968
1962	27.102	27.88	.129
1963	28.305	27.77	.639
1964	29.970	27.69	.839
1965	31.779	27.02	
1966	32.509	22.69	

*Av. of Good and Choice Feeder Steers at Kansas City, July through June

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Figure 4

cows kept on farms January 1 and beef calves kept on farms January 1 is specified as follows:

(5) $$V = \alpha C$$

where α is estimated as $\frac{V_{t-12}}{C_{t-12}}$.

THE BULL INVENTORY

The number of beef bulls kept on farms is again dependent on the number of beef cows kept in breeding herds. The observed number per 100 cows changes as the average size of breeding herds changes and as new techniques such as artificial insemination are adopted. The number of beef bulls per 100 beef cows has gradually drifted downward from about 10 in 1948 to about 5-1/2 this year. The relationship between beef bulls and cows is:

(6) $$B = \beta C,$$

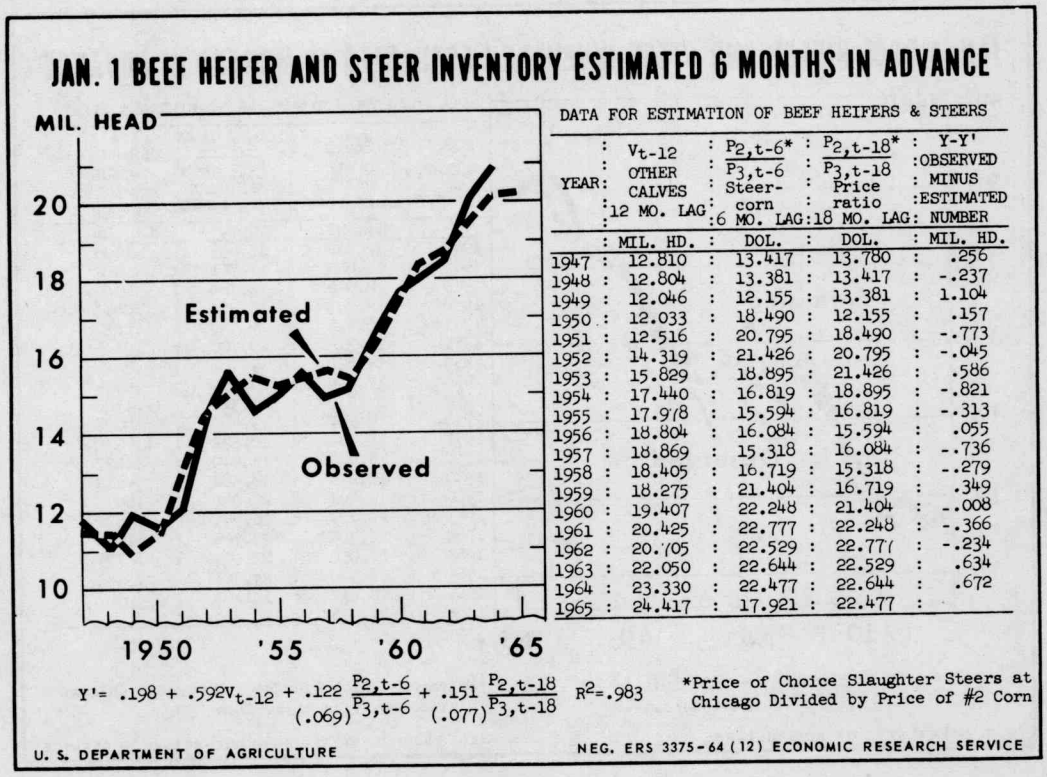
where β is estimated by $\frac{B_{t-12}}{C_{t-12}}$.

THE BEEF STEER AND HEIFER INVENTORY

The number of calves on farms January 1 serves as a pool from which the inventory of heifers 1 to 2 years old and steers 1 year and older is drawn the following year. The number drawn from this pool and kept rather than slaughtered depends on the expected returns from slaughtering these calves at a later date, compared to the expected costs of keeping them. Many of these cattle are sold as fed cattle and for this reason fed-cattle prices would indicate the expected returns. Expected costs would depend on feed prices. The relationship between the number of beef steers and heifers kept on farms January 1, beef calf numbers, fed-cattle prices, and feed prices is:

(7) $$Y_t = a_3 + b_6 V_{t-12} + b_7 \frac{P_{2,t-6}}{P_{3,t-6}} + b_8 \frac{P_{2,t-18}}{P_{3,t-18}}.$$

This fitted relationship, the estimated values of Y, and the observed values of Y are shown in figure 5.



DATA FOR ESTIMATION OF BEEF HEIFERS & STEERS

YEAR	V_{t-12} OTHER CALVES 12 MO. LAG	$\frac{P_{2,t-6}}{P_{3,t-6}}$* Steer-corn 6 MO. LAG	$\frac{P_{2,t-18}}{P_{3,t-18}}$* Price ratio 18 MO. LAG	Y-Y' OBSERVED MINUS ESTIMATED NUMBER
	MIL. HD.	DOL.	DOL.	MIL. HD.
1947	12.810	13.417	13.780	.256
1948	12.804	13.381	13.417	-.237
1949	12.046	12.155	13.381	1.104
1950	12.033	18.490	12.155	.157
1951	12.516	20.795	18.490	-.773
1952	14.319	21.426	20.795	-.045
1953	15.829	18.895	21.426	.586
1954	17.440	16.819	18.895	-.821
1955	17.978	15.594	16.819	-.313
1956	18.804	16.084	15.594	.055
1957	18.869	15.318	16.084	-.736
1958	18.405	16.719	15.318	-.279
1959	18.275	21.404	16.719	.349
1960	19.407	22.248	21.404	-.008
1961	20.425	22.777	22.248	-.366
1962	20.705	22.529	22.777	-.234
1963	22.050	22.644	22.529	.634
1964	23.330	22.477	22.644	.672
1965	24.417	17.921	22.477	

Figure 5

Income from feeding cattle comes from two sources: income due to the difference in the price of the feeder calf and the price of the fed animal, and income due to feeding or the weight gained by the animal on feed. The expected sum of these two incomes per head would determine whether feeders are willing to invest in more or fewer numbers of feeder cattle. Since the price of slaughter cattle relative to the price of corn is an indicator of these incomes, these prices can be used to indicate expected income to the feeder. Each time the fed cattle producer reinvests in feeder calves, which he does at least every 18 months, it is necessary for him to determine his expected income from this new investment.

In addition to this relationship another equation was specified in order to use the latest price information available in estimating steer and heifer numbers 1 year in advance. The fitted relationship is shown in figure 6. This relationship is

$$(8) \qquad Y_t = a_4 + b_9 V_{t-12} + b_{10} \frac{P_{2,t-12}}{P_{3,t-12}}.$$

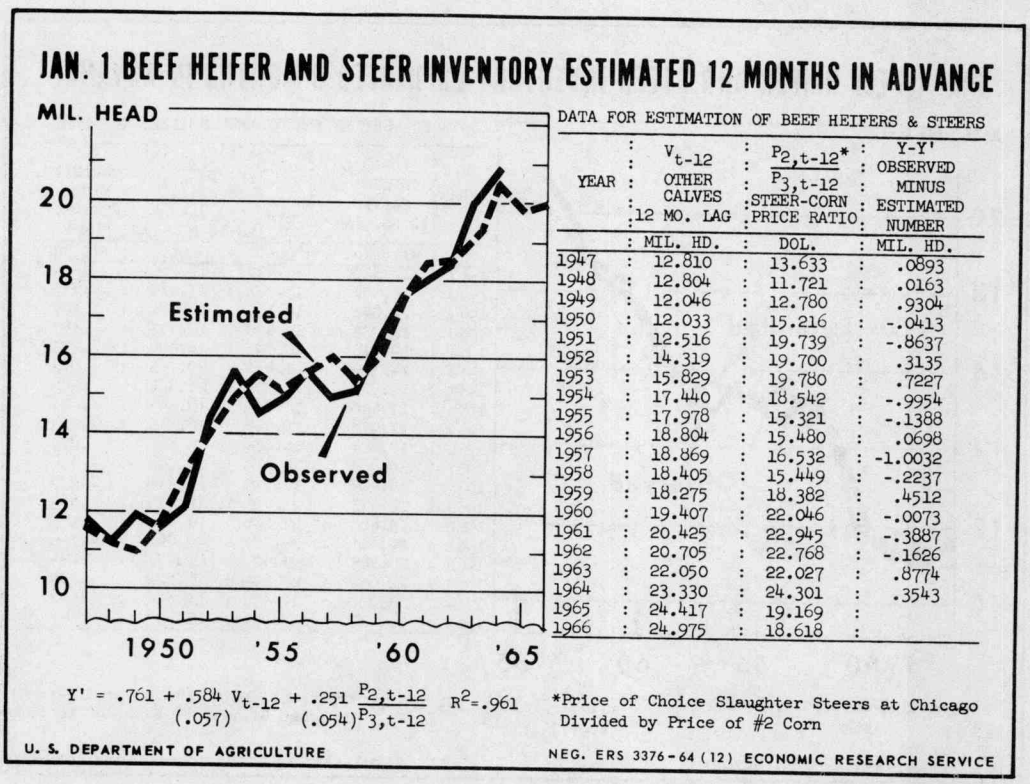
THE TOTAL INVENTORY

The total inventory results from the summation of all the classes within the inventory. Since all the independent variables in the equations are lagged by at least 6 months, conditional expectations for the number in each class may be computed 6 months and 18 months before January 1. The relationships summed to estimate the total inventory may be written as follows:

$$(9) \qquad I'_t = C'_t \left(1 + \frac{V_{t-12} + B_{t-12}}{C_{t-12}}\right) + Y'_t.$$

The values of estimated I and observed I are recorded in figure 7. The estimated values of I_t for 1966 result from using equations (3) or (4) and (8). The other estimated values of I_t (from 1947 through 1965) result from using equations (2) and (7).

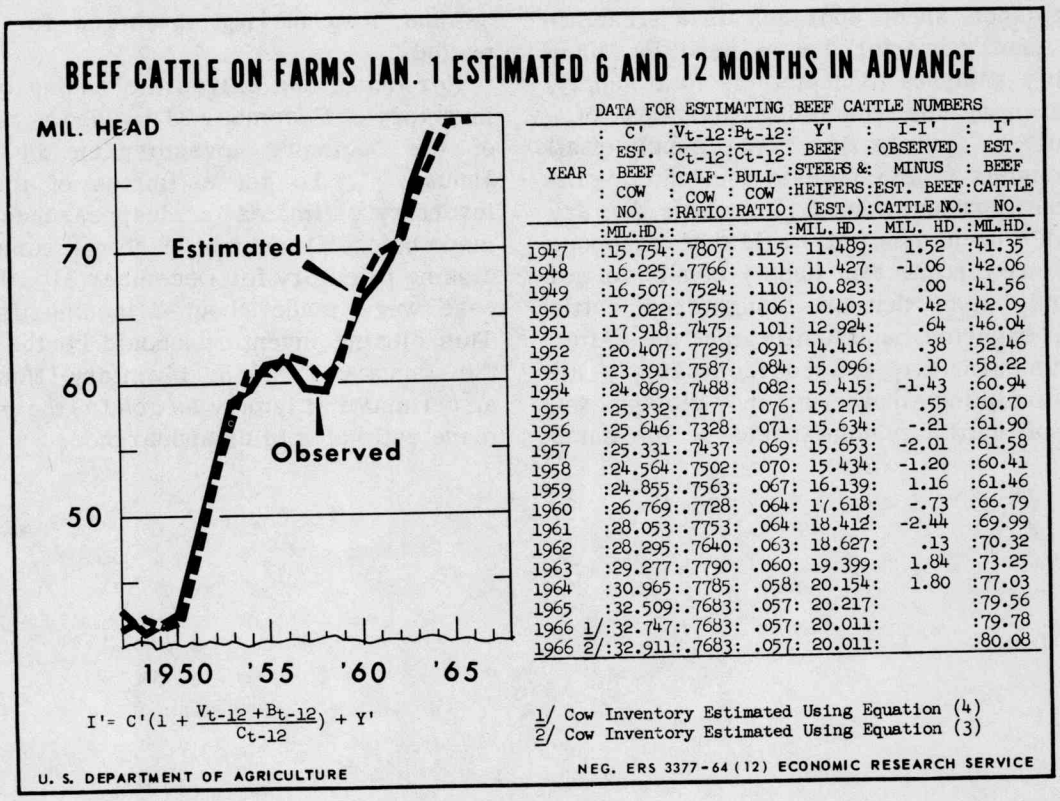
Since these estimates are based on past prices and do not always take into account some of the intangible factors it is interesting to compare the estimates for the total inventory here with



DATA FOR ESTIMATION OF BEEF HEIFERS & STEERS

YEAR	V_{t-12} OTHER CALVES 12 MO. LAG	$P_{2,t-12}/P_{3,t-12}$* STEER-CORN PRICE RATIO	Y-Y' OBSERVED MINUS ESTIMATED NUMBER
	MIL. HD.	DOL.	MIL. HD.
1947	12.810	13.633	.0893
1948	12.804	11.721	.0163
1949	12.046	12.780	.9304
1950	12.033	15.216	-.0413
1951	12.516	19.739	-.8637
1952	14.319	19.700	.3135
1953	15.829	19.780	.7227
1954	17.440	18.542	-.9954
1955	17.978	15.321	-.1388
1956	18.804	15.480	.0698
1957	18.869	16.532	-1.0032
1958	18.405	15.449	-.2237
1959	18.275	18.382	.4512
1960	19.407	22.046	-.0073
1961	20.425	22.945	-.3887
1962	20.705	22.768	-.1626
1963	22.050	22.027	.8774
1964	23.330	24.301	.3543
1965	24.417	19.169	
1966	24.975	18.618	

Figure 6



DATA FOR ESTIMATING BEEF CATTLE NUMBERS

YEAR	C' EST. BEEF COW NO.	V_{t-12} / C_{t-12} CALF-COW RATIO	B_{t-12} / C_{t-12} BULL-COW RATIO	Y' BEEF STEERS & HEIFERS (EST.)	I-I' OBSERVED MINUS EST. BEEF CATTLE NO.	I' EST. BEEF CATTLE NO.
	MIL. HD.			MIL. HD.	MIL. HD.	MIL. HD.
1947	15.754	.7807	.115	11.489	1.52	41.35
1948	16.225	.7766	.111	11.427	-1.06	42.06
1949	16.507	.7524	.110	10.823	.00	41.56
1950	17.022	.7559	.106	10.403	.42	42.09
1951	17.918	.7475	.101	12.924	.64	46.04
1952	20.407	.7729	.091	14.416	.38	52.46
1953	23.391	.7587	.084	15.096	.10	58.22
1954	24.869	.7488	.082	15.415	-1.43	60.94
1955	25.332	.7177	.076	15.271	.55	60.70
1956	25.646	.7328	.071	15.634	-.21	61.90
1957	25.331	.7437	.069	15.653	-2.01	61.58
1958	24.564	.7502	.070	15.434	-1.20	60.41
1959	24.855	.7563	.067	16.139	1.16	61.46
1960	26.769	.7728	.064	17.618	-.73	66.79
1961	28.053	.7753	.064	18.412	-2.44	69.99
1962	28.295	.7640	.063	18.627	.13	70.32
1963	29.277	.7790	.060	19.399	1.84	73.25
1964	30.965	.7785	.058	20.154	1.80	77.03
1965	32.509	.7683	.057	20.217		79.56
1966 1/	32.747	.7683	.057	20.011		79.78
1966 2/	32.911	.7683	.057	20.011		80.08

1/ Cow Inventory Estimated Using Equation (4)
2/ Cow Inventory Estimated Using Equation (3)

Figure 7

estimates made using a balance sheet approach. The estimated December 31 closing inventory compares with the following January 1 beginning inventory. The two estimates are never exactly equal because the beginning inventory and the supply and disappearance factors are all results of independent surveys. This balance sheet is shown in table 2.

Table 2.--Balance sheet for dairy and beef cattle on farms, 1947-64

Year	Total supply (dairy and beef)				Disappearance					Estimated closing total inventory Dec. 31	Dairy cattle inventory	Estimated closing beef cattle inventory Dec. 31
	Beginning inventory Jan. 1	Calves saved	Imports	Total supply	Slaughter: Cattle	Slaughter: Calves	Exports	Death loss of cattle and calves	Total disappearance			
	1,000 head											
1947.....	80,554	34,703	85	115,342	22,404	13,726	10	3,930	40,070	75,272	36,169	39,103
1948.....	77,171	33,125	462	110,758	19,177	12,378	7	3,635	35,197	75,561	35,270	40,291
1949.....	76,830	33,748	433	111,011	18,765	11,398	5	3,840	34,008	77,003	35,455	41,548
1950.....	77,963	34,899	461	113,323	18,614	10,501	8	3,742	32,865	80,458	35,398	45,060
1951.....	82,083	35,825	238	118,146	17,084	8,902	8	3,863	29,857	88,289	35,235	53,054
1952.....	88,072	38,273	140	126,485	18,625	9,388	11	4,034	32,058	94,427	35,921	58,506
1953.....	94,241	41,261	198	135,700	24,465	12,200	15	4,060	40,740	94,960	36,161	58,799
1954.....	95,679	42,601	86	138,366	25,889	13,270	21	4,063	43,243	95,123	35,342	59,781
1955.....	96,592	42,112	314	139,018	26,587	12,864	35	4,052	43,538	95,480	34,209	61,271
1956.....	95,900	41,376	159	137,435	27,755	12,999	37	3,912	44,703	92,732	33,291	59,441
1957.....	92,860	39,905	728	133,493	27,068	12,353	44	3,801	43,266	90,227	31,962	58,265
1958.....	91,176	38,860	1,152	131,188	24,368	9,738	26	3,810	37,942	93,246	30,708	62,538
1959.....	93,322	38,938	709	132,969	23,722	8,072	51	3,876	35,721	97,248	30,181	67,067
1960.....	96,236	39,353	663	136,252	26,026	8,611	32	4,098	38,767	97,485	29,974	67,511
1961.....	97,319	39,911	1,043	138,273	26,467	8,081	24	4,008	38,580	99,693	29,550	70,143
1962.....	99,782	40,961	1,250	141,993	26,905	7,854	19	4,112	38,890	103,103	28,651	74,452
1963.....	103,512	41,744	852	146,108	28,059	7,198	20	4,032	39,309	106,799	27,654	79,145
1964.....	106,260	42,563	[1] 600	149,423	[1] 31,145	[1] 7,490	[1] 20	[1] 4,100	42,755	106,668	[1] 27,000	79,668

[1] These are estimates made October 1.

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The balance sheet approach is a straightforward and powerful device used by many commodity analysts to depict the total supply, disappearance, and remaining inventory of a commodity at a given time. Total supply of all cattle consists of the January 1 inventory plus the calves born and saved plus cattle that are imported. The number of cattle that disappear or are taken from this supply consist of all cattle and calves that are slaughtered, cattle that are exported, and cattle that die. After these numbers are deleted from supply all cattle remaining make up the closing inventory of cattle, which should be the same as the beginning inventory for the next period.

For cattle and calves the ending or closing inventory of December 31 is used as an estimate of the beginning inventory on the following January 1. To get estimates of the closing inventory estimates of disappearance must be made before December 31. The estimates of the closing inventory for December 31, 1964, in this case were made about 3 months in advance. This closing inventory should be the same as the January 1, 1965, inventory. However, as an estimator it is only as good as the previously made estimates of disappearance.