Comparing the 1990's With Past Cycles of Cattle Inventories

The previous section summarized a great deal of the mechanics and history of cattle cycles, beef production, beef price spreads, and meatpacker consolidation. This information is helpful in seeing the paths taken by the beef industry to arrive where it is today. We now turn to the more specific objectives of this report, to characterize cattle cycles and price movements to determine whether the cycle of the 1990's was atypically worse than the cattle cycles preceding it in terms of cattle numbers, changes in cattle numbers, prices, price spreads, or changes in prices or price spreads. Also, we determine whether the cattle cycle of the 1990's, in fact, exhibits signs that various segments of the industry are taking unfair advantage of other segments. Specifically, is the cycle of the 1990's characterized by unexpectedly lower returns to cow/calf producers and cattle feeders because of the high level of concentration and continuing consolidation within the beefpacking sector? And, are price spreads an indicator of this alleged exercise of market power?

First, we need to demonstrate whether the cycle of the 1990's exhibits more extreme high or low levels of relevant economic variables than expected, given the behavior of these variables during previous cycles. A review of the literature does not yield many studies that compare specific cattle cycles with other cycles. Crom's study (1981), following the severe cattle cycle of the 1970's, is one of the few studies that characterizes cattle cycles in a statistical sense. Crom identified price, expenditure, and output variables affecting or affected by the amplitude of cattle inventory cycles and estimated the magnitude of their effects. He observed considerable variation in steer prices, retail prices, consumer expenditures per person, and the value of the January 1 cattle inventories. Coefficients of variation ranged from 9 percent (retail prices) to 25 percent (value of January 1 cattle inventory in real dollars), up to 54 percent (consumer expenditures in nominal dollars) for the period 1950-79.

We extended Crom's (1981) general methodology by estimating and comparing variances, coefficients of variation, and means, and by performing other general comparative tests on selected variables. In addition to extending Crom's methodology, we investigated the behavior of cattle and calf inventories and prices by examining correlation coefficients between some more important cattle sector variables.

A question arose during this research about which was more important in affecting cattle inventory behavior, lagged variables as the basis for producers' expectations or future values of variables as expectations. To investigate this question about the role of expectations in inventory dynamics, we included both leading and lagged values of variables in a regression model from which we briefly summarize the results (see box).

Next, we wanted to know if price spreads exhibited unusual behavior during the cycle of the 1990's. Finally, we wanted to know if packer concentration allowed packers to significantly influence cattle cycles. To accomplish these latter objectives, we specified an asymmetric model of farm, wholesale, and retail prices to examine price spreads. With this asymmetric model, we examined price spreads, the relationship between price spreads and the cattle cycle, and the relationship between price spreads and packer concentration. We also used the asymmetric model to simulate expected price movements to see what prices would have looked like over the cattle cycle under a set of restricted conditions.

Data

Data for this study of cattle inventory cycles are annual data and are available back to 1867 for some variables. Almost all variables are available back to 1935, and some are available back to about 1913. In some cases, backcasts were made to extend a data series backward in time, for example, with costs and gross value of production before 1972 (app. table 1). Variables used in the analysis included cattle and hog inventories, farm level prices, cow/calf production costs and gross value of production, value per head, corn prices, various productivity indices, deflators, and other variables.

The prices used in our asymmetric model to explain net-farm, wholesale, and Choice beef retail price movements are from the series ERS uses to calculate price spreads. The Choice beef price spread is a measure of the total difference between the reported price received by producers for a Choice, yield grade 3 live animal (less noncarcass byproducts) and the weighted average price paid for the fresh Choice beef cuts from the animal in retail foodstores. A wholesale boxed-beef value is also calculated such that the total farm-to-retail spread is divided into two component spreads, the farm-to-wholesale spread and the wholesale-to-retail spread. For part of this analysis, the data were transformed so that farm and wholesale prices are expressed in retail weight equivalents. This transformation allowed us to calculate a price spread by subtracting the price at one level from the price at another level.

The Role of Expectations as Drivers of the Cattle Cycle

Producers' expectations about what will happen to them in the context of the cattle industry is one important source of factors affecting aggregate cattle inventory changes. These expectations combined with the biological lags inherent in adjusting cattle inventories have implications for the cattle cycle. The literature is divided on the role that expectations play in the expansion and contraction of beef cattle inventories. There is as yet no clear consensus in the literature about what decisionmakers consider, that is, what is in their information sets and when they make their herd adjustment decisions. Much literature regarding cattle cycles prior to the 1980's cycle rationalized that higher current and past cattle and calf prices motivated heifer retention for herd building (for example, Jarvis, 1974; Arzac and Wilkinson, 1979, p. 307; and Nelson, 1984). That is, these authors rationalized that high prices observed in the current period would motivate heifer retention and inventory buildup. However, other authors, especially since the 1970's cycle, suggest a somewhat reverse mode of expectation formation by looking into the future (Rucker, Burt, and LaFrance, 1984; Trapp, 1986; Rosen, Murphy, and Schienkman, 1994). Trapp (1986, p. 702), in his simulation of optimal herd dynamics, emphasized the role of expectations when he suggested that, in practice, the optimal "[c]ulling and replacement strategies must anticipate the feeder cattle price cycle by some four to six years." Indeed, Trapp (1986, p. 700) observed that "the most rapid rebuilding phase for the herd occurs when profit per head is lowest or even negative." He found negative returns for the first 3 years of his simulated feeder cattle price cycle, during the expansion phase of the simulated cattle cycle, and that "[t]he optimal herd size exhibits cyclical patterns that peak and bottom three years ahead of the feeder steer price cycle" (p. 700).

Using leading values of variables as expectations variables is related to rational expectations and is referred to as "implicit expectations" (Mills, 1957, and Lovell, 1986). According to Lovell (1986), Mills' (1957) implicit expectations differ from rational expectations through the assumption that the prediction error term is assumed uncorrelated with the actual realization, whereas Muth's (1961) rational expectations assumes that the error term is uncorrelated with the predicted value.

We found no clear evidence in the literature suggesting that leading variables are better at describing inventory behavior than lagged variables or vice versa. In related work only briefly reported here, we examined directions of causality, using correlation analysis, as above, and regression techniques. We found that leading variables have more explanatory power than lagged variables, but lagged variables appear to have larger effects on cattle and calf inventories. Generally, the leading variables were more significantly different from zero than were the lagged variables, but the lagged variables had slightly larger parameter esimates. The coefficient for current cattle prices per hundredweight was significant and negatively related to cattle and calf inventories, indicating that high prices in the current period may result in sales of cattle and low prices may result in cattle being held off markets. This result supports the idea that producers are motivated to sell cattle during periods of high prices rather than retaining them for purposes of herd expansion. Current and expected corn prices had a generally positive effect on current cattle and calf inventories, while lagged prices had no significant effect in our simple model. Inventories are often thought to depend on the number of calves born in previous periods, so it was surprising that the size-of-calf crop variables had no effect on cattle and calf inventories.

Statistical Comparisons of Cycles

Our first formal hypothesis was that the cycle of the 1990's was no worse than any other previous cycle.[4] We set up a hypothesis of "no worse than" (a null hypothesis) because it is easier to reject something (like "no worse than") than it is to try and prove the opposite ("is worse than") is true. That is, if we can demonstrate evidence for some difference, then we can reject our null hypothesis of "no difference" without necessarily knowing exactly what makes the difference. More specifically, if we can demonstrate some evidence that the 1990's cycle is not the same as other cycles, then we can reject our null hypothesis. If we can reject our null hypothesis, we can say there is evidence to support the contention that the cycle of the 1990's is somehow different than previous cycles. In some cases, we examined the entire data series, while in other instances, we examined each cattle cycle or specific statistics for each cattle cycle taken across cattle cycles. For instance, we examined the mean of real net returns above cash costs over the period 1913-90 and the mean of individual cycle means.[5]

Means, Variances, and Coefficients of Variation

The first question we asked was, how did cow/calf producers fare during the cycle of the 1990's and during previous cycles? The average (mean) per-cow real net returns above cash costs for the 1913-1990 series was $56.18 in 1982-84 dollars. Looking at cycle statistics, the mean real net returns above cash costs for the eight cattle cycles before the 1990 cycle was $52.66 in 1982-84 dollars. The mean for the 1990's cattle cycle, through 1997, was $17.46, well within a 95-percent confidence interval (-$14.40, $119.70) based on the series variance. Variability, measured by the coefficient of variation (ratio of the standard deviation to the mean of a variable) of real net returns for the first 6 years of the current cattle cycle is 2.587. The series coefficient of variation for before 1990 is 1.012. The coefficient of variation for means of real net returns for the last eight cattle cycles before 1990 is 0.64.

As a further test, we wanted to know if there was a difference in how real net receipts above cash costs varied over cycles before 1968, the last year of the cycles preceding the 1970's, and cycles from 1968 to the present. Net returns above cash costs and their cyclical averages have trended downward, which is later discussed. However, a simple F test (ratio of variances) of variances of real net receipts above cash costs between the three consecutive cattle cycles ending in 1967 (variance of 194.12) and the three consecutive cycles beginning in 1968 (variance of 198.05) did not show a significant difference in variability between the two periods.

Cattle price volatility is another way the situation could be worse during the cycle of the 1990's. However, real (1982-84 dollar) cattle prices appear less volatile relative to their means than real net returns. The mean real cattle price per cwt for the period 1935-96 was $66.55. A 95-percent confidence interval around the mean of $66.55 encompasses an interval from a high of $97.50 to a low of $35.61. No annual real average price per cwt was below lower bound of the 95-percent confidence interval, although there were two instances where high prices were higher than the upper bound of the 95-percent confidence interval. The lowest real price was $37.41 in 1996. Prices in 1950 and 1951 (the year of the highest average real price, $114.19) were higher than the upper bound of a 95-percent confidence interval. The variance for prices over the same period was 239.4049 (standard deviation the =15.4727), yielding a coefficient of variation of 0.2325.

All actual values of per-capita pounds of beef and veal consumption on a carcass-weight basis were within the 95-percent confidence interval bounds. The highest per-capita beef and veal consumption was 131.5 pounds in 1976, the lowest, 61.5 pounds in 1943.[6] Per-capita consumption showed relatively low volatility, with a coefficient of variation of 0.21.

Relative Changes in Selected Variables

[4]"Worse" in this context means "adversely affecting" cattle producers, such as returns below some lower bound of a confidence interval, or inventories above some upper bound.

[5]We will distinguish between the two sets of statistics by calling the statistic for an entire series the series statistic and the statistic across cycle subseries statistics the cycle statistic.

[6]Per capita beef and veal consumption was lower in 1932, at 53.3 pounds, but outside the data range of this specific analysis.

from Previous Cattle Cycles

Real net receipts above cash costs during 1996 (the second lowest real net receipts above cash costs since 1913) were -$48, just over half the -$79 loss observed in 1975, but within a 95-percent confidence interval of annual real net receipts. Real net receipts above cash costs have trended downward since 1913 (simple regression slope of -1.17613, t-statistic of -5.3), as has the average per cycle of net receipts above cash costs over the last eight cattle cycles (slope = -10.7891, t-statistic = -3.16).

The longest string of consecutive years with negative real net receipts above cash costs occurred from 1981 through 1986, exceeding the series of losses from 1974 through 1977 and 1995 through 1996. April 1997 calf prices were $91 per cwt, roughly 53 percent higher than April 1996's $59.30 (USDA, *Livestock, Dairy and Poultry Situation and Outlook*, April 16, 1997). Cow prices in April 1997 were, however, $39 per cwt, only 13 percent over April 1996's $34.44. Percentage changes in cattle and calf prices from Apri1 1996 to April 1997 for other weights and classes of cattle were between these extremes, suggesting that nominal and real net receipts above cash costs for 1997 will be positive.

Several factors help account for differences in the severity of the last three cattle cycles. President Nixon's beef price freezes, oil price shocks, drought, and extremely high grain prices compounded the adjustment in cattle numbers in the 1970's. The peak in cattle inventories during the cattle cycle of the 1970's was also the historical peak in cattle inventory numbers. Both subsequent cattle cycles peaked at inventories substantially below the 1975 peak (fig. 1). In fact, the inventory peaks for the two cattle cycles since the 1970's have been successively lower. However, these successive declines in cattle inventory numbers have been at least partially offset by a shift in beef cattle production technology that increased average pounds of beef produced per cow per year. Beef produced per cow has increased more than 100 pounds per cow since the first half of the cycle in the 1980's. Total annual beef production has remained over 25 billion pounds per year since 1994. It peaked at 25.7 billion pounds in 1998, the same as in 1976. The ability to produce more beef with fewer cows precipitated adjustments in cattle numbers during the previous and current cattle cycles. This is because fewer cattle are needed to produce the same amount of beef. Drought also occurred in the 1980's and in 1996. The improved technology combined with the 1996 combination of drought and high grain prices compounded the adjustment in cattle inventories during the mid-1990's.

At the same time that cattle cycles seem to be generating years of greater losses in real dollars, annualized rates of increase in cattle numbers from the beginning of each cattle cycle expansion to the cyclical peak in cattle numbers appear to be declining. During earlier cycles, cattle numbers increased at an average annual rate of 4 percent or more. During the last two cycles, expansions occurred at a 1.2-percent annual rate. This decline in the rates of increase in cattle numbers suggests that cattle producers may be becoming more astute at adjusting herds in the face of the cattle cycle. Information, including price and demand information, is more widely and readily available and perhaps is being used in herd management decisions.

Most of the last eight cattle cycle expansions have taken 6 to 8 years from low to peak. The shortest expansion, taking only 3 years from low to peak, was during the 1980-90 cycle. In addition, cattle numbers have increased between 17 and 30 percent from each cycle's low in numbers to its peak, with only two exceptions: the cycle of 1980-90 and the current cycle. The percentage increase from 1980-82 was just under 4 percent, and for the current cycle that began in 1991 was just under 8 percent. While these rates of buildup look somewhat erratic, a glance at total beef production shows an increase of almost 14 percent from low to peak for the 1980's cycle and just over 12 percent for the 1990's cycle. Also, beef production peaked at 24.2 billion pounds during the 1980's cycle, in line with trends in beef production for previous cycles and the 1990's, but excluding the huge jump in beef production during the cycle of the 1970's.

Many papers have been written suggesting ways to overcome or take advantage of cycles in livestock production, but the beef cattle cycle persists. There are at least two reasons why beef cattle cycles may persist: One, the very seasonal production technology may force producers to postpone adjustments in breeding herds. Two, other than military meat procurement and school lunch program purchases, there are no government programs, support prices, or other policy interferences with the beef cattle markets. Therefore, there is no way to assess prices in future periods with any degree of certainty as there was with target prices and other fiat prices that, in the past, provided price floors for grains. It is interesting to observe that dairy cow numbers are not behaving cyclically, having ceased robust cyclical behavior during the 1970's.

Correlations

Correlations tell us how closely variables move together. Correlations can suggest causal relationships. In our study, correlation coefficients between cattle cycle variables yielded some interesting results (table 1), not all of which were as one would expect given price-quantity relationships suggested by economic theory. The correlations observed with the highest t-values were between per-capita beef and veal consumption and cattle and calf numbers, between per-capita red meat consumption and cattle and calf numbers, and between changes in per-capita red meat consumption and cattle and calf numbers.

All correlations between various measures of final products could be expected to vary from a strict one-to-one accounting correspondence because of substitution between species meats and because of some slippage due to imports and exports. At 0.95 (t value = 24.08 (Ezekiel, 1930, p. 256)), the positive relationship between per-capita beef and veal consumption and cattle and calf numbers was the highest and most statistically significant observed correlation and was close to the one-to-one relationship one might expect. There is not a lot of leeway in capacity to store beef once cattle reach slaughter weight or after they have been slaughtered, even when frozen. The second highest correlation, also related to per-capita consumption was the 0.95 (t value = 23.16) for per-capita beef and veal consumption and total per-capita red meat consumption. Following closely was the 0.93 (t value = 19.17), measuring a direct relationship between total cattle and calf inventories and total per-capita red meat consumption.

Given constant costs or costs that steadily increase or decrease, one could expect close to a one-to-one relationship between returns and output prices. Real returns per cow and cattle prices in real dollars per hundredweight were correlated at 0.93 (t value = 18.85). Real receipts per cow were also correlated with real dollars per hundredweight, 0.81 (t value =10.47). This less than perfect correlation is due to fluctuations in feed prices, oil prices, interest rates, and prices of other inputs. The correlation between the change in net returns above cash costs and the change in cattle numbers was -0.52 (t value = -4.67). This negative correlation between the change in net returns above cash costs and the change in cattle numbers would seem to support Trapp's (1986) observation that simulated cow herd expansion optimally occurs during periods of negative returns.

Economic theory leads one to expect an inverse relationship between quantities and prices, but modified somewhat by quantities and prices of substitutes and complements. The correlation between changes in cattle and calf numbers and changes in cattle price per cwt was at -0.45 (t value = -3.89), again the expected inverse relationship, but not as large as expected, given the changes in farm level income observed in the data and given the causality arguments encountered in some of the earlier literature and the popular press.

Table 1--Correlation coefficients and t-statistics for cattle cycle variables, 1935-96

Variable	All hogs and pigs	Per-capita beef and and veal consumption	Costs per cow	Total cattle and calves	Change in cattle and calf inventory from previous year	Change in net income above cash costs from previous year	Change in corn price from previous year
Per-capita beef and veal consumption	-0.0342 (-.26)						
Costs per cow	.2615 (2.08)	0.1483 (1.15)					
Total cattle and calves	.1061 (.82)	.9527 (24.1)	0.3031 (2.44)				
Change in cattle and calf inventory from previous year	.3623 (2.99)	-.2311 (-1.82)	.0096 (.07)	-0.0460 (-.35)			
Change in net income above cash costs from previous year	-.1216 (-.94)	.0047 (.04)	-.0872 (-.67)	-.0982 (-.76)	-0.5200 (-4.67)		
Change in corn price from previous year	.1883 (1.47)	-.0502 (-.39)	-.0911 (-.70)	-.0312 (-.24)	.1879 (1.47)	0.1333 (1.03)	
Change in per-capita beef and veal consumption from previous year	-.0748 (-.58)	.0414 (.32)	-.0504 (-.39)	.0517 (.40)	.4229 (3.58)	-.4480 (-3.84)	0.1771 (1.38)
Change in cattle price per hundredweight from previous year	-.0222 (-.17)	-.1439 (-1.12)	-.0135 (-.10)	-.2168 (-1.71)	-.4510 (-3.89)	.7878 (9.82)	.0944 (.73)
Total red meat per-capita consumption	.2187 (1.74)	.9492 (23.16)	.2015 (1.58)	.9283 (19.17)	-.1130 (-.87)	-.0480 (-.37)	-.0002 (-.001)
Net returns above cash costs per cow	.3288 (2.67)	-.5398 (-4.93)	.2236 (1.76)	-.5276 (-4.77)	-.0160 (-.12)	.3991 (3.34)	.1813 (1.42)
Corn price	.1290 (1.00)	-.5199 (-4.67)	.4094 (3.45)	-.4093 (-3.45)	.2438 (1.93)	-.0220 (-.17)	.3072 (2.48)
Per-capita pork and lamb consumption	.7614 (9.02)	-.3413 (-2.79)	.1307 (1.01)	-.2536 (-2.01)	.3961 (3.31)	-.1570 (-1.22)	.1591 (1.24)
Year	.0441 (.34)	.7482 (8.66)	-.0257 (-.20)	.7194 (7.95)	-.2250 (-1.78)	-.0650 (-.50)	-.0360 (-.27)
Real gross receipts per cow	.3773 (3.13)	-.3957 (-3.31)	.5749 (5.40)	-.3256 (-2.65)	-.0100 (-.07)	.3013 (2.43)	.1170 (.90)
Real price of cattle per hundredweight	.3180 (2.58)	-.1637 (-1.27)	.7044 (7.62)	-.0525 (-.40)	.1849 (1.44)	.1457 (1.13)	.0307 (.24)

Continued--

Table 1--Correlation coefficients and t-statistics for cattle cycle variables, 1935-96--Continued

Change in per-capita beef and veal consumption from previous year	Change in cattle price per cwt	Total per-capita red meat consumption	Real net returns per cow	Real price of corn	Per-capita pork consumption	Year	Real receipts per cow
-0.6620 (-6.79)							
.0637 (.49)	-0.0540 (-1.20)						
-.3560 (-2.93)	.4922 (4.34)	-0.4250 (-3.61)					
.2411 (1.91)	.1018 (.79)	-.4380 (-3.75)	-0.4628 (4.01)				
.0587 (.45)	-.0020 (-.02)	-.0280 (-.22)	-.4439 (3.80)	0.3420 (2.80)			
-.1570 (-1.22)	-.1540 (-1.20)	.6788 (7.10)	-.4390 (-3.75)	-.7590 (-8.95)	-0.3490 (-2.86)		
-.3190 (-2.58)	4080 (3.43)	-.2790 (-2.23)	.9261 (18.85)	.5470 (5.02)	.4232 (3.59)	-0.3784 (-3.14)	
-.2330 (-1.84)	.3239 (2.63)	-.0540 (-.42)	.6537 (6.33)	.5231 (4.71)	.3573 (2.94)	-.3675 (-3.04)	0.8064 (10.47)