Price Spreads and the Cattle Cycle

Producers note that the farm value share of the Choice beef retail price declined from nearly 70 percent in the 1970's to below 50 percent in 1996 (figs. 3 and 4). During the same period, the nominal farm-to-retail price spread widened from less than 40 cents per pound to over a $1.40 per pound (figs. 3 and 5). Many producers believe these figures indicate improper pricing behavior by marketing firms, especially beefpackers. However, previous studies have found conflicting evidence to support such contentions (see next chapter, "Concentration Measures for the Beef Packing Industry").

Long-Term Fluctuations

Looking at nominal price spread data versus deflated price spread data gives a different perspective on long-term price spread patterns. On a nominal basis, wholesale-to-retail and farm-to-wholesale price spreads for Choice beef have increased dramatically since the 1970's (figs. 3 and 5).

But when adjusted for inflation, the wholesale-to-retail spread has fluctuated within a relatively constant band, while the farm-to-wholesale spread has declined substantially (figs. 5 and 6). The services provided by beefpacking firms (processing and packaging) have increased over time, and the cost of those services has risen.

The index of food marketing costs, a measure of changes in the costs of marketing inputs such as labor, packaging, transportation, energy, and other inputs, increased four-fold from 1968 to 1994, from 103.5 to 435.0 (Elitzak, 1998). The farm value share is low, partly because marketing cost changes have paralleled inflation while cattle price changes have not. Decreasing farm value share is a characteristic of most agricultural commodities and signifies to some extent improved technological efficiencies. The farm value share for all U.S. domestically produced farm foods was 40 percent in 1952, 33 percent in 1960, 32 percent in 1970, 31 percent in 1980, 24 percent in 1990, and 21 percent in 1997 (http://www.econ.ag.gov/briefing/foodmark/cost/data/bill/value.htm).

Short-Term Fluctuations

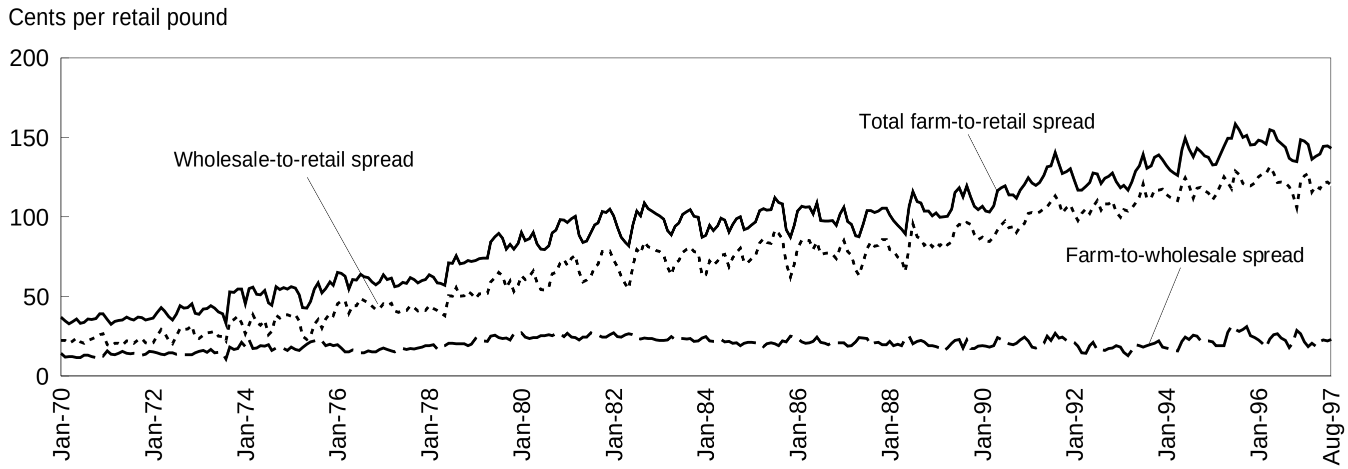
Short-term fluctuations in beef price spreads stem largely from the lag observed between price changes at the farm and retail levels. Retail prices are more rigid than commodity prices at least partly because retailers set prices for advertising purposes weeks ahead, and because they believe consumers prefer more stable prices.

ERS research shows that price adjustments at farm and wholesale levels are nearly concurrent using monthly data (fig. 7). The retail price follows price changes at the farm and wholesale levels with a lag distributed over almost a year. Retail price adjustments are asymmetric (upward movements in farm prices are followed about 24 percent more quickly at retail than are downward price movements). Retailers possibly expect that downward movements are likely to be temporary and wish to avoid marking prices down then back up again. This asymmetry provides one justification for our asymmetric model of price changes described in a later section and in Appendix B.

For example, from April to May of 1994, the net farm value of Choice beef declined 15 cents, the wholesale value dropped about 9 cents, and the retail price went up about 1 cent. In May and June, the net farm value dropped another 12 cents, the wholesale value again fell 9 cents, and the retail price moved down about 5 cents. The retail price continued to decline through August, even though farm and wholesale prices increased in July and August. As a result of the lags in price changes at the retail level, the spread tends to widen in the short term when prices are falling, and narrow, but to a lesser extent, when prices are rising.

Figure 3

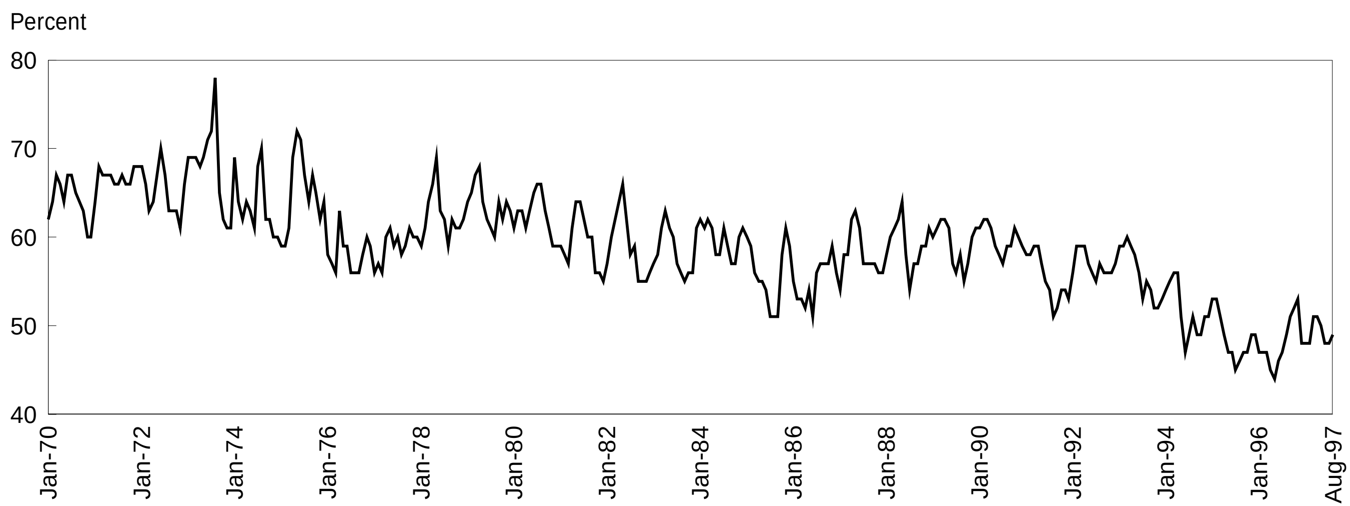
Farm-to-wholesale, wholesale-to-retail, and total price spreads for beef (Choice, yield grade 3), January 1970-August 1997



Note: Average by month, January 1970-August 1997.
Source: USDA, ERS.

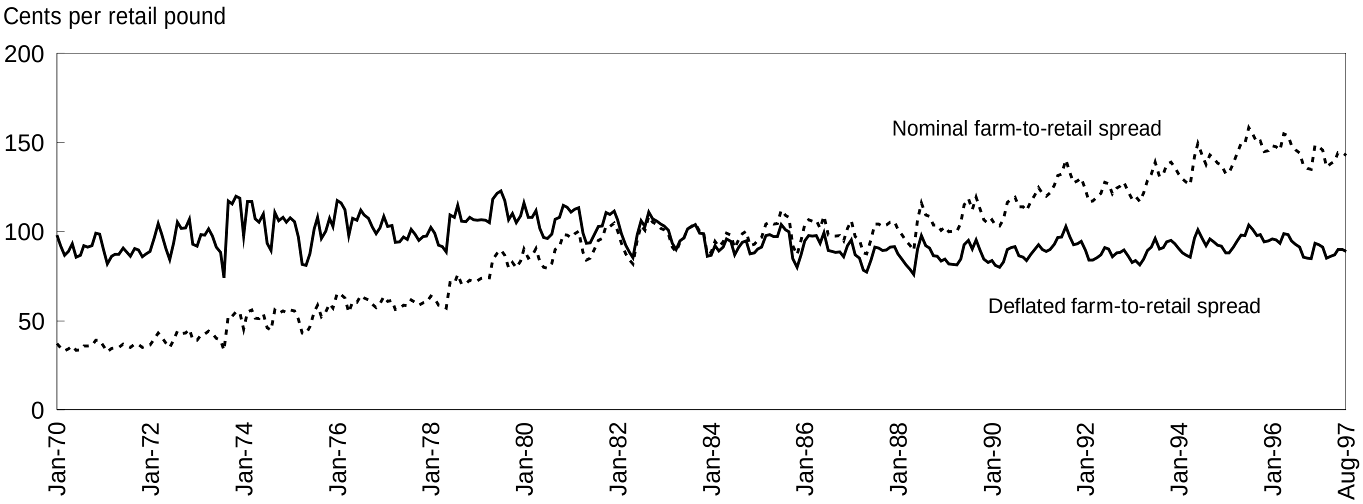
Figure 4

Farm share of retail price for beef (Choice, yield grade 3), January 1970-August 1997



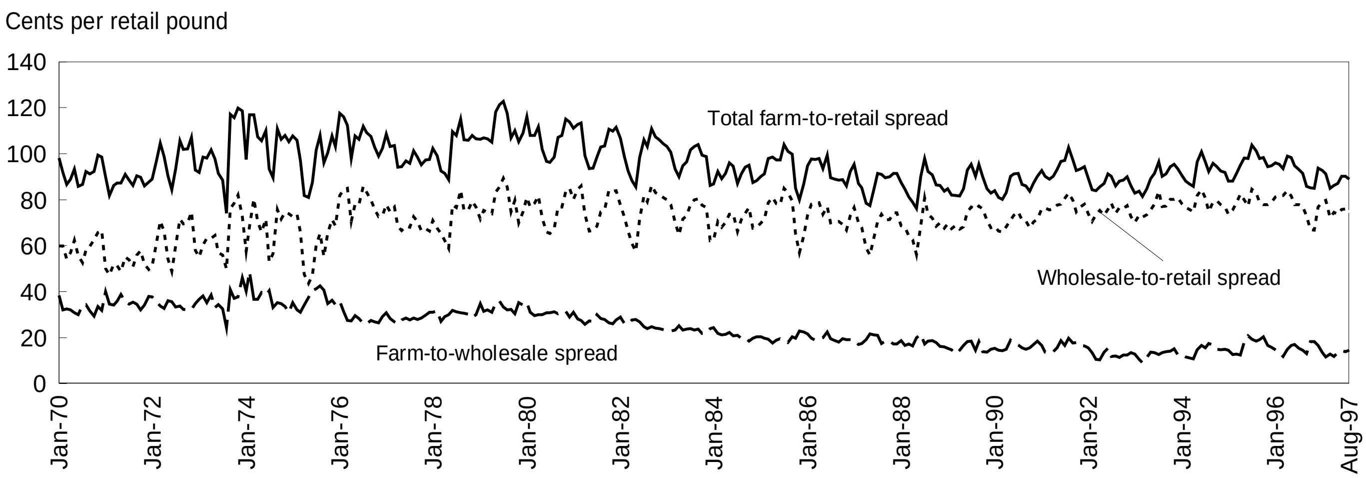
Note: Average by month, January 1970-August 1997.
Source: USDA, ERS.

Figure 5
Farm-to-retail spreads, nominal and deflated, for beef (Choice, yield grade 3), January 1970-August 1997



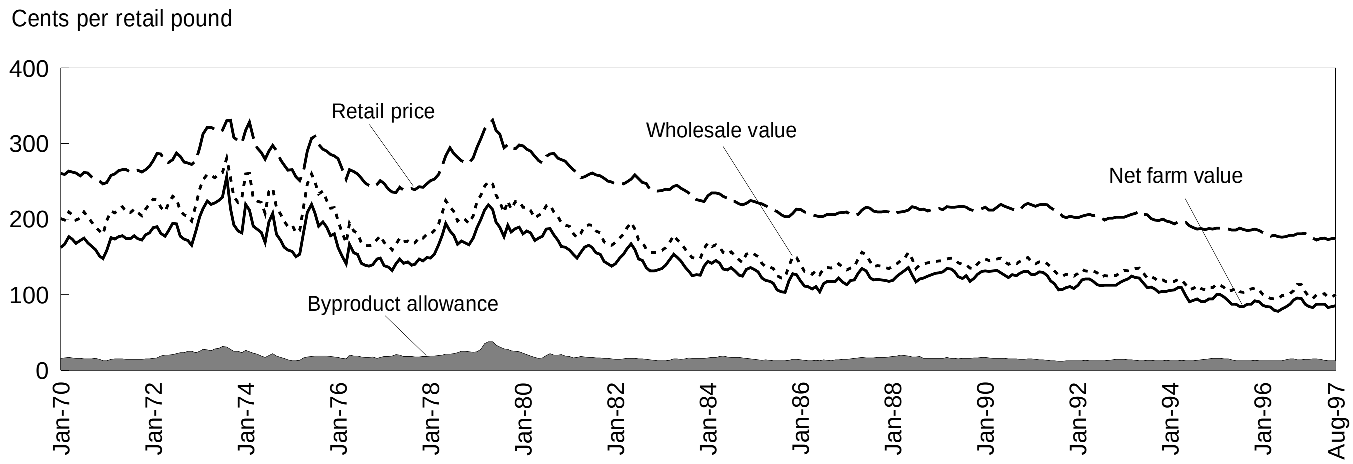
Note: Average by month, January 1970-August 1997. Deflator is Consumer Price Index, United States, all urban, all items, 1982-84=100.
Source: USDA, ERS.

Figure 6
Farm-to-wholesale, wholesale-to-retail, and total price spreads: Deflated prices for beef (Choice, yield grade 3), January 1970-August 1997



Note: Average by month, January 1970-August 1997. Deflator is Consumer Price Index, United States, all urban, all items, 1982-84=100.
Source: USDA, ERS.

Figure 7
Retail price, wholesale value, net farm value and by-product allowance: Deflated prices for beef (Choice, yield grade 3), January 1970-August 1997



Note: Average by month, January 1970-August 1997. Deflator is Consumer Price Index, United States, all urban, all items, 1982-84=100.
Source: USDA, ERS.

General Structure of a Price Spread Adjustment Model

We address several issues concerning price spreads, cattle cycles, and packer concentration, especially for the 1990's cattle cycle, to respond to the allegations that packers (because of their alleged market power) and the 1990's cycle had an extremely adverse effect on producers. One issue is whether prices and price spreads change at the same rate when prices are increasing as when prices are decreasing (asymmetry of price and price spread behavior). A second issue is whether there was an unexpected shift in prices during the 1990's cattle cycle. A related third issue is the effect that the cattle cycle had on price spreads. A fourth issue is the effect of packer concentration on price and price spread behavior. This section addresses the first three issues. The fourth issue is discussed in the next chapter with the use of the asymmetric model.

To examine the first three issues, we needed a model of prices and price spreads that would allow us to explain what happens to farm-, wholesale-, and retail-level prices and price spreads.[7] Economists have estimated many models where the farm price moves first and drives the wholesale price, which in turn drives the retail price. One advantage of these traditional models is that, if the other prices are following the farm price, economists interested in explaining price spread movements do not have to worry about why the farm price changes, they have only to track how the other two prices react to the farm price. We estimated these effects and effects of the cattle cycle on price spreads by using an asymmetric, endogenous switching model that indirectly explains price spreads. Price spreads are modeled indirectly by first explaining movements in farm, wholesale, and retail prices of cattle and beef. Once we have explained the movements of these three prices, we indirectly explain the spreads between these prices.

The asymmetric model we developed for this report (see Appendix B) was based on previous research on price interactions in pork and beef markets (Hahn, 1989 and 1990). The model was designed to be flexible and to allow the past history of price spreads to determine as much of the outcome as possible. The model allowed price interactions to be either very simple or very complex. Not only can it take time for prices to adjust to changes in market conditions, but the speed at which they adjust can change, depending on the direction they are going. In our case, the endogenous variables that we explain are the net-farm, wholesale, and retail beef prices.

[7]Variables are natural logarithms of underlying variables. A “change” in prices is a difference in logarithms of two successive prices. The logarithm of a negative number is undefined.

Our model, like the traditional models, allows for slow price transmission from one level of the market to another. That is, it allows, though it does not require, retail price adjustments to lag behind wholesale price changes. However, we made our model more flexible in that we did not prespecify one price as the leader and the others as followers. Instead, our model allows the retail, wholesale, or farm price to drive the others, letting the data pick the leading price variable. Our model also allows for the case in which all three prices interact simultaneously. This extra flexibility requires that our model also have the ability to explain the general level of prices as well as their spreads.

The switching part of the name describes the ability of the model's algebraic coefficients to change, depending on the direction the variables are going. If increasing price coefficients are the same as decreasing price coefficients, then the relationship is symmetric. If, however, increasing prices can have different coefficients than decreasing prices, then the relationship is asymmetric, hence, the asymmetric part of the descriptive name for our model.

As we mentioned earlier, one of the notable features of beef prices is that farm and wholesale prices are more volatile than retail prices. Also, it often appears that retail prices follow farm and wholesale prices, with a lag of about a month. That is, retail prices tend to go up a month or more after the others go up and drop a month or more after the others drop. Retail prices will follow wholesale prices if it takes time for retail prices to adjust to changes in the wholesale price.

The real world is more general than most models would suggest. In addition to determining prices, the beef market also determines beef production and allocates product to domestic and international markets. Our model focuses only on prices at three levels of the beef marketing chain. Our model is based on the assumption that we can pull the pricing parts of the market out of the system as a whole and study their effects. The rest of the marketing structure is collapsed into the terms that determine the target price spreads and levels.

We assume that the longrun price level is determined by other, more general, supply and demand factors. We model these effects using information on supplies of beef and pork, consumption of beef, pork, chicken, and turkey, and on other variables that shift the demands for and supplies of meats. The supply and demand shifters include seasonality and trends, including technological change. Our explanation of long-term price spreads is relatively simple. We assume that these grow with inflation along their longrun trend. This assumption is consistent with what we think we see in the raw data (see the discussion above on long-term fluctuations).

The shortrun effects of supply and demand shifts on prices will vary from the longrun effects unless the model has complete, not partial, adjustment. In addition to the effects of partial adjustment on prices, shortrun and longrun effects can vary for other reasons, particularly if there is some shortrun feedback from price changes to quantity changes. This type of feedback seems particularly likely, especially between prices and demand.

To help differentiate between the shortrun and longrun effects of the other variables, we divided most of our explanatory variables into two parts, the change from the previous month (shortrun elasticities) and last month's value (longrun elasticities). This month's value is the sum of those two parts. Our explanatory variables also include intercepts, trends, and seasonal factors; for mathematical reasons, these intercept shifters cannot be meaningfully split into this month's change and last month's value. (Knowing last month's value is the same as knowing this month's value for these terms. Knowing last month's beef production is helpful in predicting this month's production, but there is still plenty of room for surprises.) A complete list of explanatory variables and their parameter estimates can be found in table 2. Except for the intercept, trends, and seasonal factors, the explanatory variables we used are the natural logarithms of the underlying variables.

We used the monthly consumer price index (CPI) to factor out inflation in current price changes and lagged prices. The farm, wholesale, and retail prices of beef were also divided by the average value of the deflated retail price. By doing this, the coefficients of the supply and demand variables could be interpreted as elasticities at the retail price level.

Table 2--Asymmetric Model Estimates, equations

Variables	Price level	Farm-to-wholesale spread	Wholesale-to-retail spread
Increasing endogenous:			
Retail	0		2.6951
Wholesale	2.9796	3.9760	0
Net farm	0	-3.5088	
Decreasing endogenous:			
Retail	.9686		3.5528
Wholesale	3.6695	4.5720	-.0903
Net farm	.0381	-3.6091	
Lagged endogenous variables:			
Retail	-.7573		-1.0000
Wholesale	0	-1.0000	1.0000
Net farm	-.2427	1.0000	
Exogenous variables:			
Intercept	1.2745	.1327	.3518
Intercept shift	.0790	.0176	.0367
Trend	-.0511	-.0047	-.0022
Seasonal effects (these are constrained to sum to zero):			
January	.0122	.0053	.0058
February	-.0234	-.0226	-.0057
March	-.0180	-.0234	-.0073
April	.0130	.0117	.0071
May	.0074	.0291	.0173
June	-.0276	.0044	.0104
July	-.0312	-.0174	-.0031
August	.0016	-.0070	-.0106
September	.0153	.0059	-.0117
October	.0061	.0004	-.0097
November	.0143	.0005	-.0010
December	.0303	.0130	.0086
Shortrun elasticities (at the mean, deflated retail price):			
Per-capita beef disappearance	.2249	.1387	.0540
Per-capita pork disappearance	.5129	.2084	.0235
Per-capita chicken disappearance	.3498	.0025	.0650
Per-capita turkey disappearance	.0382	.0154	.0140
Commercial beef production	-1.0335	-.2152	-.3527
Commercial pork production	-.3046	-.1521	.1471
The CPI for food	4.9675	.6917	2.7809
Per-capita consumption expenditures	-.8363	-.4459	-.7186
The price of corn	-.0383	.0518	.0321
The price of soybean meal	.1338	.0801	.0285
The price of hay	.1814	.0533	.1016
Longrun elasticities (at the mean, deflated retail price):[1]			
Per-capita beef disappearance	-.5608		
Per-capita pork disappearance	-.4153		
Per-capita chicken disappearance	.5003		
Per-capita turkey disappearance	-.0025		
Commercial beef production	-.0555		
Commercial pork production	.3235		
The CPI for food	.4506		
Per-capita consumption expenditures	.4133		
The price of corn	.0076		
The price of soybean meal	.0153		
The price of hay	.0518		

[1]The "elasticities" do not correspond to either demand or supply elasticities. They are a combination of both.

Estimation Results and Interpretations

Estimating endogenous switching models is difficult because they are not included in standard econometric software. They can be estimated using general mathematical optimization software. We set up the equations that we estimated for the convenience of the software we used, General Algebraic Modeling System (GAMS), and also to make it easier to impose coherent (sensible) parameter values. We estimated our model using maximum likelihood estimation and monthly data, previously described, beginning in 1979, and running to the end of 1996.

One disadvantage of using optimization software is that it does not provide us with measures of the standard errors of individual coefficients, so we have to use tests that do not depend on parameter standard errors. We used likelihood ratios to test two hypotheses, one for asymmetry of price behavior, and a second for a recent shift in price behavior.

The first test was for the importance of asymmetry. In previous work, Hahn (1989 and 1990) found that pork and beef prices generally responded asymmetrically. That is, they reacted more quickly when they were going up than when they were going down. In the current study, our test for asymmetry was significant at the 3-percent level. We concluded that asymmetry was important, and prices move up faster than they move down.

The second test arose from concern that recent cattle prices have been lower than expected. We added a dummy variable to each equation to capture shift in pricing in the last 5 years of the sample (1992-96, inclusive). These three dummy variables, tested as a group, had a huge test statistic. The odds of observing such a number by chance would be less than 1 in 10,000. We accepted the hypothesis that there has been a shift in cattle pricing (or technically speaking, we could not reject the null hypothesis of no shift in cattle pricing), but the shift was upward, not downward as the allegations motivating this study suggested. In other words, prices were actually higher during the last 5 years than previous behavior suggested they should have been. Our estimates of the asymmetric model with pricing (intercept) shifts are in table 2.

As noted before, the behavior of the estimated model can switch depending on the direction each price is heading. With three prices and two directions for each, there are eight possible combinations of price directions. The model is relatively easy to interpret when the farm and retail prices are increasing. In the two cases where the farm and retail prices are going up and the wholesale price is going in either direction, the model can be rearranged to get a wholesale-led model, that is, one where prices are determined in steps.

When the farm and retail prices are increasing, their coefficients in the price-level equation are zero. When the farm and retail prices are increasing, only the wholesale price can react to move the general price level closer to its target. Once the wholesale price reacts, the farm and retail prices adjust. The farm price is determined by the farm-wholesale-spread equation and the retail price by the wholesale-retail-spread equation. Increasing and decreasing wholesale prices have positive coefficients in the farm-wholesale equation. This means that current price changes at wholesale cause current price changes at the farm. The wholesale price tends to move the farm price in the same direction. With farm-price coefficients smaller (in absolute value) than either wholesale price coefficient, these estimates (inverses of estimated parameter effects) imply that the farm price tends to overreact to wholesale price changes. A 1-cent change in the wholesale price tends to cause a greater change in the farm price.

Wholesale-price decreases have a small coefficient in the wholesale-retail spread equation, while wholesale price increases have a zero coefficient. This means that current wholesale price decreases have little effect on this month's retail price. Wholesale price increases have no effect on this month's retail price.

When either the farm or retail price is decreasing, the estimates imply more complex behavior. For instance, the wholesale price is affected by the farm price change in the price-level equation, while the farm price is affected by the wholesale price in the spread equation. When the retail price is decreasing, it also appears in the price level equation. As a result, none of the three prices can be selected as leading the others. When all three prices are declining, all three react to move prices closer to the target level, and all three end up being affected by the difference between actual and target spreads. Additional analysis of the three coefficients indicated that, in the short run, the wholesale price is the most sensitive to differences between target and actual price levels. More generally, while the wholesale price has an important role in getting the general price level right, its lagged value is not a factor in calculating the lagged, general price level. Its estimated coefficient is not statistically different from zero. Also, the retail price, which has very little direct response (often none) to the price level, has a very high weight.

Simulations and Forecasts With the Asymmetric Model

We used our asymmetric model to simulate and forecast prices and spreads to examine the issues of a shift in the behavior of recent prices and the effect of cattle inventory cycle behavior on price spreads.

Beef/Cattle Price Shifts

As noted above, our estimates imply that there was an important shift in the behavior of the system in the past 5 years, but it was actually a shift in favor of cattle producers. We simulated two sets of price forecasts to evaluate the pattern of beef prices in the last 3 years of our sample. These forecasts can be seen in figures 8, 9, and 10. The first set of forecasts used coefficients based on all the data, 1979-96. These are the in-sample forecasts.

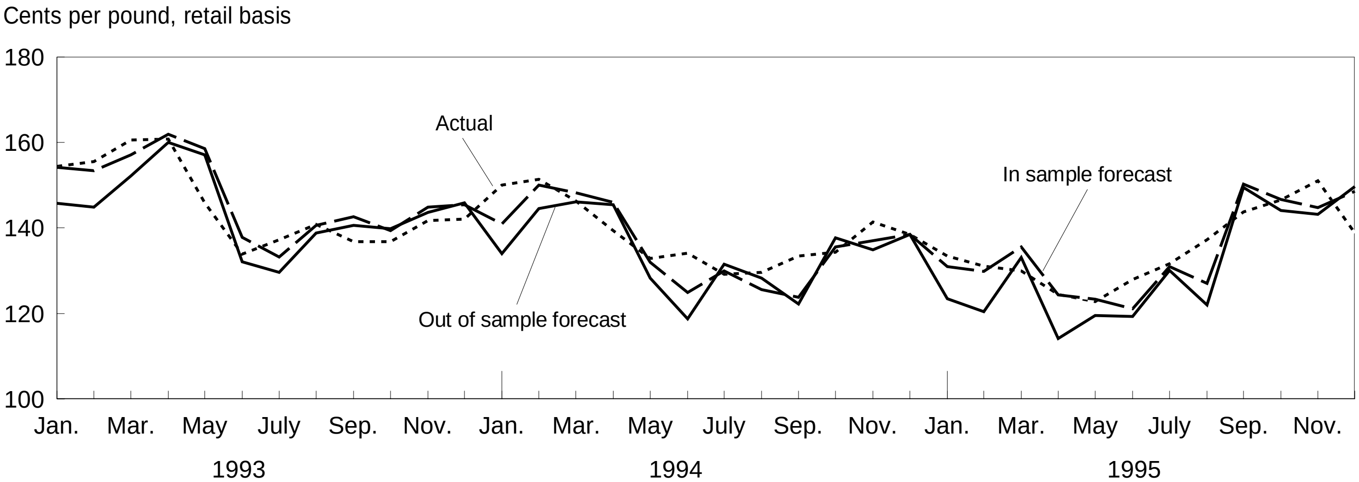
The shift in cattle pricing in the last 5 years caused cattle, wholesale, and retail beef prices to be higher than they would have been given their earlier pattern of reaction to supply and demand shocks. On average, farm and wholesale prices are 6.6 cents per retail-pound equivalent higher than they would be without the shift, and retail prices are 3.8 cents per pound higher. The farm-wholesale price spread has been unaffected by the shift, and the wholesale-retail spread has dropped. The out-of-sample forecasts are based on the coefficients estimated, using only the 1979-91 data. Note that the out-of-sample forecasts are generally lower than in-sample forecasts, further evidence that the recent shifts in the system led to higher prices.

We simulated beef prices under a series of alternative scenarios to see the effects of changes in selected scenarios on beef price spreads. Starting with January 1991, we simulated beef prices given: fixed beef production and consumption, fixed pork consumption and production, and fixed production and consumption of chicken and turkey. All other explanatory variables in the model were fixed.

Like all econometric models, ours deals mostly in predicting averages, that is, the average set of price changes one would expect given a certain set of conditions. Usually, an average set of changes will be different from the actual set of changes. That is why we built error terms into each of the equations. To make the simulated values as much like the original values as possible (except for the factors we changed), we added the estimated errors back to each of the equations. That way, the only difference between the actual and simulated prices would be the different levels of meat production and consumption.

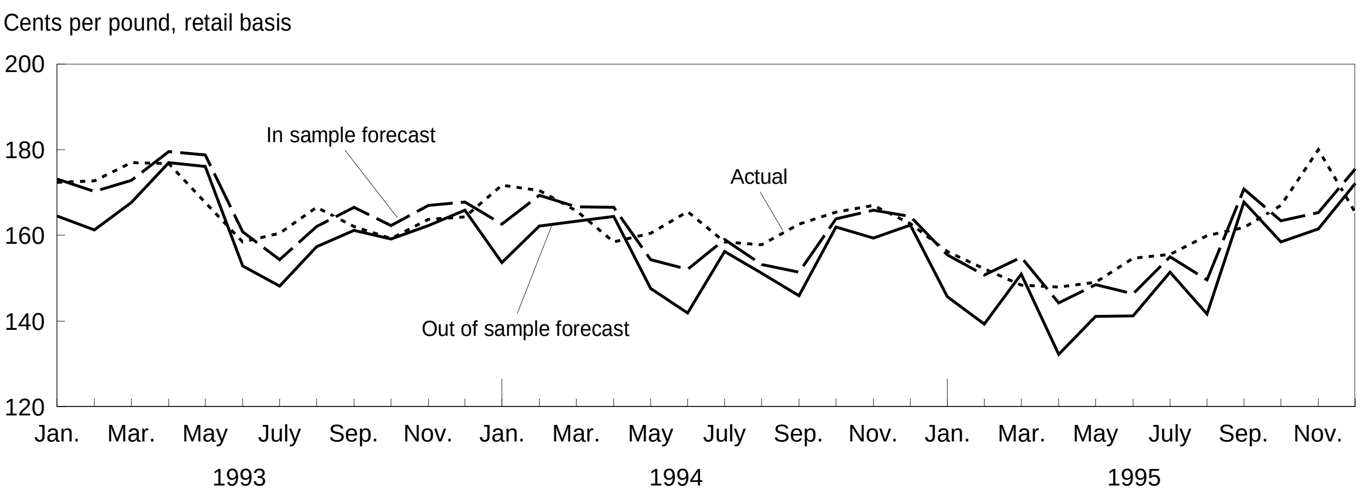
To no one's surprise, we found beef quantities were much more important in determining beef prices than the quantities of the other meats. Pork, chicken, and turkey quantities had only minor effects on December 1996 beef prices. Had beef production and consumption been steady since 1991, beef prices at all levels would have been noticeably higher, 15 to 20 cents per retail weight equivalent. Price spreads were much less affected by the changes in beef, pork, or poultry quantities. The largest part of the difference there occurred in the wholesale-retail spread, which was caused by the slow adjustment of the retail price.

Figure 8
Net farm values for beef, January 1993-December 1995



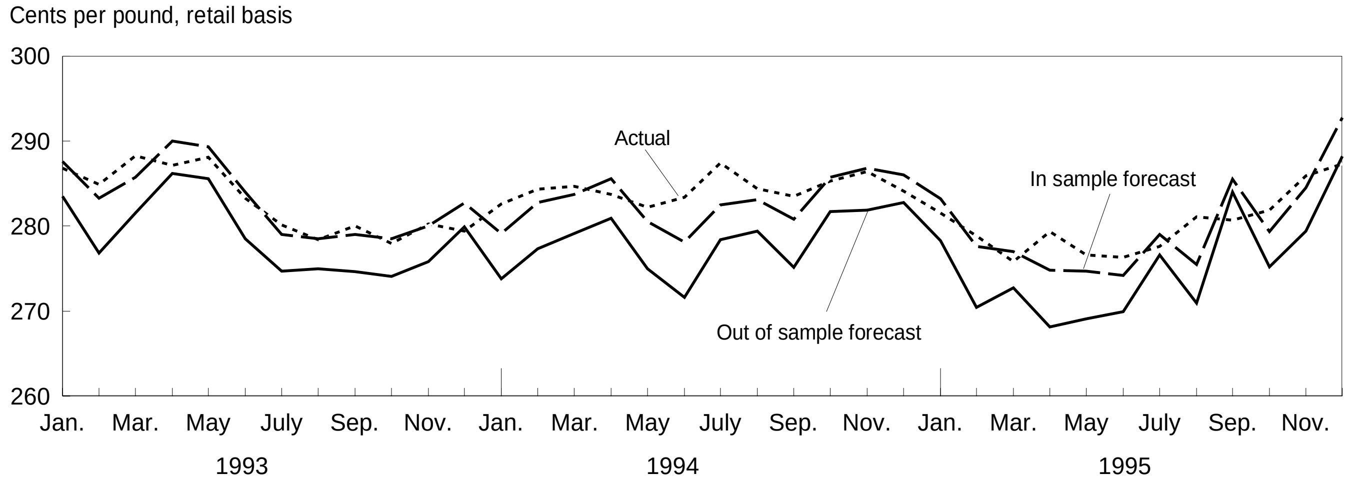
Source: USDA, ERS.

Figure 9
Wholesale values for beef, January 1993-December 1995



Source: USDA, ERS.

Figure 10
Retail values for beef, January 1993-December 1995



Source: USDA, ERS.

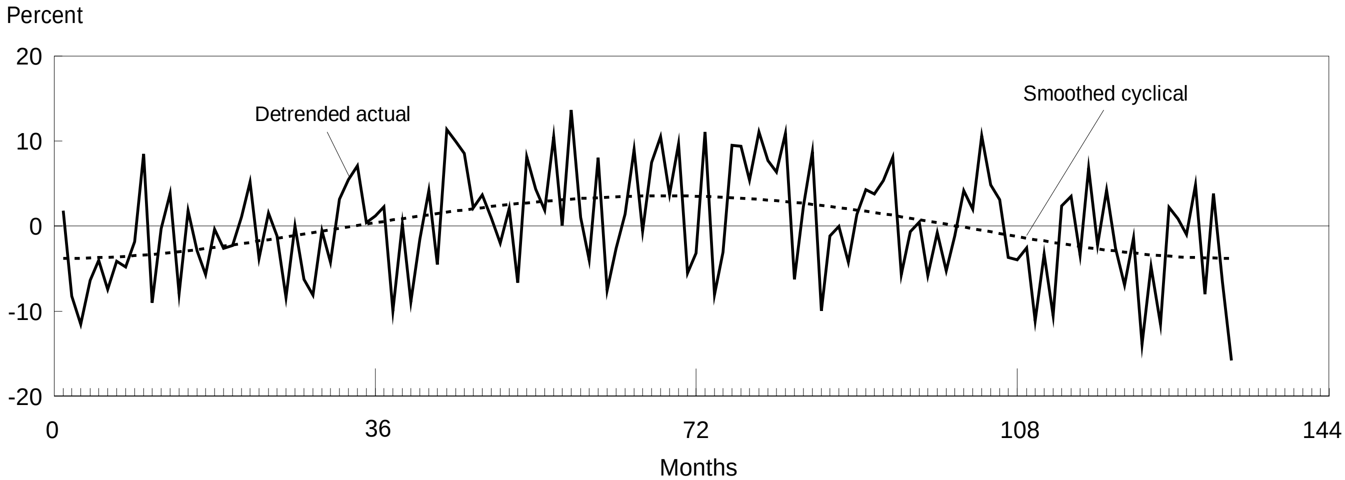
Cattle Cycle Effects

We used model simulations to see how the cattle cycle affected price spreads, in part, to see if there were price spread behaviors that depended on where in the cattle cycle they were. Econometricians often talk about dividing data series into trend, cyclical, seasonal, and transient components. We took the actual patterns of beef production and consumption from the 1980-90 cattle cycle and extracted the trend and cyclical parts (figs. 11 and 12). Since the cattle cycle implies relatively smooth changes in quantities from one month to the next, most of the month-to-month changes in beef quantities are due to the seasonal and transient parts, leaving a smooth pattern of prices (figs. 13 and 14). Further, the slow nature of cyclical quantity changes does not put much stress on price adjustment. As a result, we found almost no cyclical pattern in the price spreads themselves.

We simulated the effects of the cattle cycle by running only the cyclical parts of beef production and consumption through the model, with every other variable fixed. (We also eliminated the seasonal factors from the model.) We ran our simulation as a closed loop, that is, as if the cycle ran continuously forever. Our resulting prices represent a purely cyclical set. Figures 13 and 14 show prices and price spreads over the cattle cycle. Prices (fig. 13) show a definite cyclical pattern, varying almost 10 percent at the farm level over the cycle. Wholesale prices vary similarly, but not quite as extremely over the cattle cycle. Retail prices vary the least over the cattle cycle, varying only about 4 percent over the cycle.

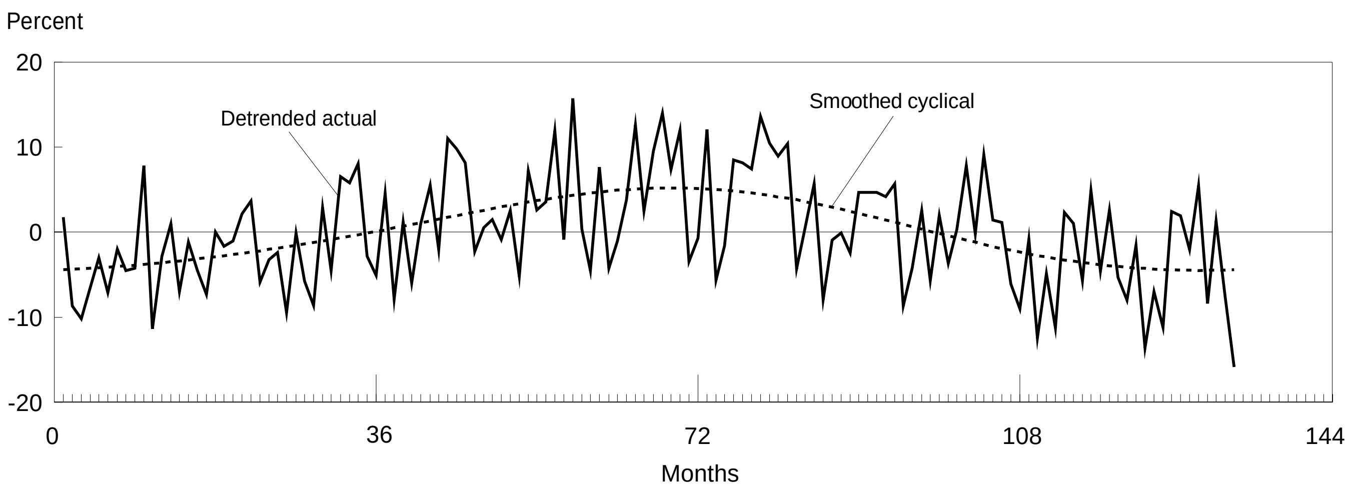
Price spreads also vary over the cattle cycle (fig. 14), but not much (less than 2 percent from peak to trough, and the three spreads are virtually identical). This is not to say that changes in cattle numbers are irrelevant to price spreads. The purely cyclical component of quantity changes is just not extreme enough to cause the wide changes in price spreads actually observed. Other variables, the higher frequency seasonal and transient changes (not shown in figs. 13 and 14), have greater effects on price spreads than do the cyclical components of prices and price spreads.

Figure 11
Beef production over the cattle cycle



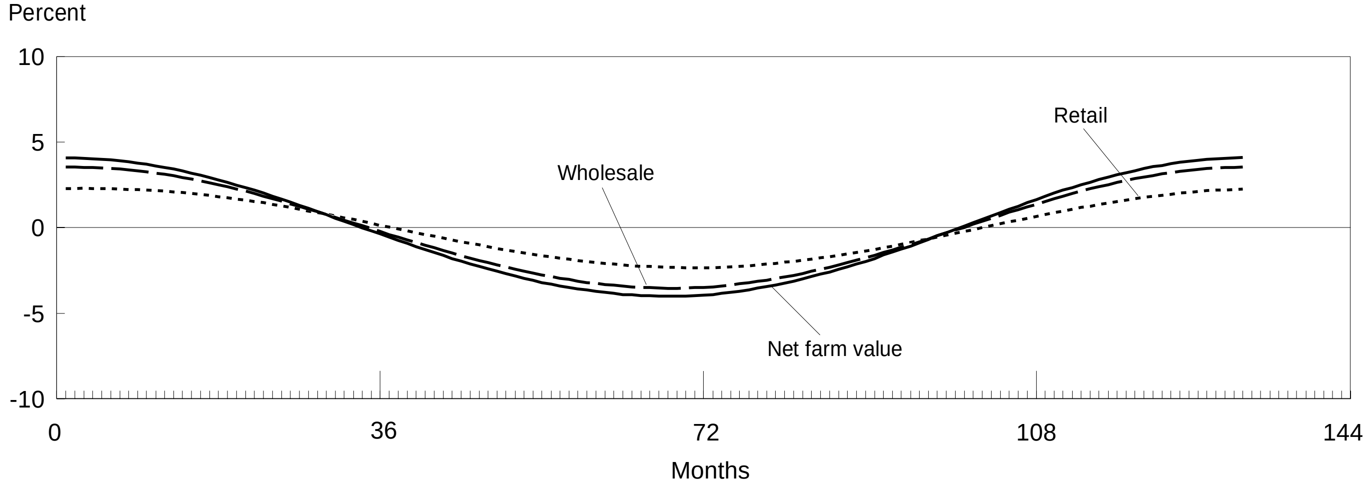
Note: The months start from the beginning of the cycle.
Source: USDA, ERS.

Figure 12
Per capita beef disappearance over the cattle cycle



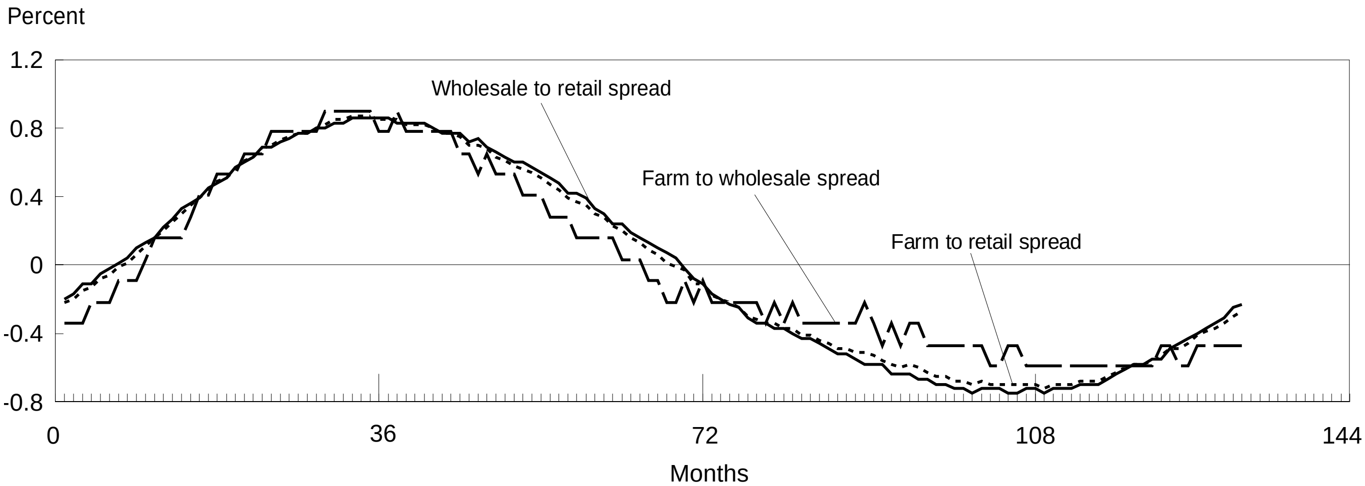
Note: The months start from the beginning of the cycle.
Source: USDA, ERS.

Figure 13
Deviation from average price over the cattle cycle



Note: The months start from the beginning of the cycle.
Source: USDA, ERS.

Figure 14
Deviation from average over the cattle cycle



Note: The months start from the beginning of the cycle.
Source: USDA, ERS.