DYNAMIC PRICE ADJUSTMENTS BETWEEN COMMERCIAL AND PUREBRED CATTLE MARKETS

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Abstract

Vector autoregression was utilized to investigate dynamic relationships existing between prices of purebred bulls and prices of slaughter steers, utility cows, feeder calves, and cow-calf pairs. Results suggest purebred bull prices respond most quickly to an increase in utility cow prices (proxy for slaughter bull prices). Feeder calf prices exhibited the most pronounced positive effect on the price of herd sires, with a lagged response which took over two years to build.

Key words: cattle prices, vector autoregression, price adjustments.

Several studies over the years have focused on the price structure of cattle markets. Price differences between steers and heifers have been examined (Buccola and Jessee; Schultz and Marsh; Buccola) as have movements between prices of feeder calves, slaughter cattle prices, and several "causal" variables (Bessler and Brandt; Spreen and Shonkwiler; Franzman and Walker; Barksdale et al.; Ehrich; Marsh). While attention has concentrated on the commercial production of cattle destined for slaughter, very little research has been devoted to the economics of the purebred industry in the United States. Although registered or purebred enterprises comprise a small portion of the total cattle sector, they are considered guardians of the industry's genetic pool and thus are a basic input supplier to commercial cattle herds.

Unlike the commercial industry, producers in the purebred industry have no terminal public market for the disposal of their product. The vast majority of purebred bulls are sold by private treaty with the remainder being sold through consignment or private production auction sales. Purebred bulls are also normally sold by the head rather than on a per-pound basis as with commercial cattle. With these marketing methods, and because of the variation in cattle quality, no uniform price is established for pure-bred cattle as for feeder or slaughter cattle in the commercial markets (Wendland).

Many "rules of thumb" have been developed by cattleman for determining the value of service-age bulls, such as "the value of five calves" the bull will sire (Merrill, p. 370). In theory, it is presumed that the derived demand for purebred bulls is related to the expected biological performance the bull will pass on to his offspring, the buyer's expectations of profitability over the serviceable life of the bull, and the price of slaughter bulls. The buyer's expectations of profitability would come largely from expectations of feeder calf and slaughter cattle prices. The price of slaughter bulls serves two purposes; first, it reflects an alternative use for the bull, and second, the money obtained from cull bulls is often used as the seed money for purchasing new ones.

While a joint dependency between feeder and slaughter prices has been suggested by Spreen and Shonkwiler, Franzman and Walker, and Barksdale et al., no such relationship has been shown to exist between commercial and purebred prices. In fact, complaints are often heard in purebred circles that price adjustments are slow between feeder calf prices and the price of purebred bulls.

This paper presents an analysis of the dynamic price adjustments which have historically occurred between purebred bull and commercial cattle prices. It specifically examines how quickly price changes in the commercial cattle markets disseminate into the purebred market. It is hypothesized that prices of purebred bulls and feeder or

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slaughter steers are not determined simultaneously as Barksdale et al. and Spreen and Shonkwiler found between the latter two. Rather, bull prices are thought to lag behind feeder and slaughter prices because bulls are purchased as capital assets and producers' price expectations of future cattle prices do not change instantaneously. It is also hypothesized that the price of slaughter bulls (alternative use for breeding bulls) has a more immediate, but shorter lived, effect upon the price of purebred bulls than feeder or slaughter steer prices. Finally, prices of purebred bulls are hypothesized to move simultaneously with changes in cow-calf pair prices because cow-calf pair prices are thought to contain producers' expectations of the value of breeding stock as well as the value of calves.

The remainder of this paper is organized as follows. First, the methodology used in this study to examine the dynamics of price adjustments (i.e., vector autoregression) is briefly discussed. Next, the model is formulated and sources of data identified. Results are then presented, after which conclusions are drawn.

METHODS OF ANALYSIS

Vector autoregression (VAR) was used to characterize the dynamic relationships between prices for commercial cattle and prices for purebred cattle. VAR analysis has been applied to the U.S. hog market by Bessler (1984a) and has been used to investigate the effect of monetary policy on agriculture by Bessler (1984b) and by Chambers. Because of the treatment of the technical aspects of VAR econometrics elsewhere (e.g., Bessler, 1984a), only a basic outline is provided.

For convenience, moving average representations of covariance-stationary stochastic processes have been derived from an autoregressive (AR) representation (Bessler, 1984a). An autoregressive process can be represented as:

$$(1)\ X_t - B_1X_{t-1} - B_2X_{t-2} - \ldots = \Phi_t,$$

where X is a linear covariance-stationary stochastic process which has m components with a mean of zero. The B_i's (where $i=1,2,\ldots$) are m by m matrices of autoregressive parameters. A white-noise innovation (error) vector is represented by Φ_t, with $E(\Phi_t) = 0$ for all t, $E(\Phi_t\Phi_s') = 0$ for $t \neq s$, and $E(\Phi_t\Phi_s') = \Sigma$ for $t = s$ (where Σ is a positive definite covariance matrix).

For analysis, the infinite series in equation (1) must be represented by a finite number of lags. The lag length must be large enough to leave only white noise and small enough to be calculated. To determine an appropriate lag length, Tiao and Box suggest a likelihood ratio statistic to test the null hypothesis $B_k = 0$ against the alternative $B_k \neq 0$, where k is the order fit. The likelihood ratio is given by the ratio of successive determinants

$$U = |S(k)|/|S(k-1)|,$$

where S(k) is the sum of squares and cross-products error matrix. The statistic

$$M(k) = -(T - ½ - k * m) \ln U$$

is asymptotically distributed chi-squared with m^2 degrees of freedom. The number of series is given by m with U defined as above and T being the number of data points over which one fits the parameters, B.

From the finite representation of equation (1), one can "simulate" the dynamic response of the vector autoregression to a unit shock in one series. This impulse response function gives the moving average representation of the process. To avoid misleading results due to contemporaneous correlation among innovations in each series, a "Wold causal chain" must be set up among current elements of the X vector. This is accomplished by applying a Choleski decomposition to the untransformed variance-covariance matrix in order to transform the variance of the transformed innovations to identity. While the ordering of the causal chain is arbitrary, economic theory can be used to determine the order of contemporaneous causation.

Using the moving average representation provided by the "simulated" AR process, one can obtain the forecast error for the r^{th} period ahead along with the associated variance-covariance matrix (Granger and Newbold). The forecast error variance can then be attributed to the innovations of each series. This allows one to "measure the strength of 'explanation' at different forecast horizons" (Bessler, 1984a, p.117).

APPLICATION OF VAR TO THE CATTLE MARKET

A five-variable system consisting of monthly prices from 1972 to 1985 (168 observations) for choice slaughter steers, utility cows, 500–600 lb. feeder calves, cow-calf pairs, and per-head prices of purebred bulls was used. Slaughter steer and feeder calf prices were included because they were thought a priori to represent the value of future offspring of the bulls. Utility cow prices were used as a proxy for slaughter bull prices because a continuous series of the latter was not available. Ordinary least square regressions showed that slaughter bull prices over the periods 1972, 1973, and 1980 through 1985 were approximately 1.25 times utility cow prices (R^2 = 0.99). Cow-calf pair prices were thought a priori to represent producers' expectations of the future value of breeding stock and feeder cattle.

Calf, utility cow, and slaughter steer prices were obtained from Amarillo Auction Sales Reports (U.S. Department of Agriculture). Cow-calf pair prices for young to middle-aged, medium and large frame, # 1 to # 2 cows, with baby to 300-pound calves at side were obtained from North Central Texas Auction Sales Reports (Texas Department of Agriculture). Purebred bull prices were obtained from the American Polled Hereford Association (American Polled Hereford Association) and the American Hereford Association monthly sale reports (*American Hereford Journal*). Bull data were reported for all private production auction and consignment auction sales. An average of 67 auction sales with 33 bulls per sale occurred each month.

The triangularization or ordering of contemporaneous correlation used in this study was slaughter steer prices (FATP), feeder calf prices (CALFP), utility cow prices (COWP), cow-calf pair prices (PAIRP), and purebred bull prices (BULLP). FATP was ordered first because fed beef comprise the largest share of beef slaughtered in the United States and all other prices were a priori assumed to adjust to the fat price. Although Spreen and Shonkwiler, Franzman and Walker, and Barksdale et al. found a joint dependency between feeder and slaughter prices, Marsh concluded that monthly premiums for calf and yearling prices adjusted to slaughter steer prices. CALFP was ordered before COWP because the number of cows going to slaughter would be highly dependent upon the prices received for feeders, and thus COWP would adjust to CALFP more readily than CALFP would adjust to COWP. PAIRP was ordered after CALFP and COWP because PAIRP was assumed to adjust to CALFP and COWP. BULLP was placed last in the ordering to reflect the belief that bull prices were more likely to adjust to the other livestock prices than vice versa.

RESULTS

The VAR model was estimated using the program RATS (Doan and Litterman). Each price series was deflated (1977=100) by the Consumer Price Index (U.S. Dept. of Commerce) and deseasonalized using the seasonal dummy command in RATS. Each variable was regressed via ordinary least squares on lagged values of itself and the remaining four variables in the system. A lag length of nine months was chosen based on the Tiao and Box U-statistics. To account for non-stationarity in the original data, a time trend was also included. Based upon the Durbin-Watson and diagnostic Q-statistics applied to within-sample residuals, no presence of autocorrelation was detected in any of the equations.

Forecast Error Variance

Decomposition of the forecast error variances and associated standard errors are shown in Table 1 for various monthly forecast horizons (r). The majority of forecast error variance for slaughter steer prices was explained by its own innovations in the first six months, with slaughter steer prices being almost exogenous in the first three months. After six months, feeder calf prices progressively accounted for a greater proportion of the forecast error variance in slaughter steer prices.

Innovations in feeder calf prices accounted for approximately one-half of the own forecast error variance throughout the 48-month period examined. Slaughter steer prices were the most predominant series in explaining feeder calf price forecast error variance, especially in the first six months.

Forecast error variance in the utility cow series was explained primarily by its own innovations at a one-month lag. From one to twelve months, approximately half of the forecast error variance in utility cow prices was explained by slaughter steer price innovations. Innovations from the feeder calf price series also constituted a relatively significant proportion of the cow price forecast error variance after the first six months.

Forecast error variance in cow-calf pair

TABLE 1. PROPORTION OF FORECAST ERROR VARIANCE r MONTHS AHEAD ATTRIBUTED TO EACH INNOVATION[a]

Forecast Error In	r	Standard Error	Innovation				
			FATP	CALFP	COWP	PAIRP	BULLP
FATP	1	2.11	100.00	0.00	0.00	0.00	0.00
	3	3.61	96.52	2.55	0.22	0.25	0.46
	6	4.19	88.50	4.88	1.84	4.16	0.62
	12	5.09	69.10	15.89	3.41	9.24	2.36
	24	5.57	62.51	20.46	3.25	9.18	4.60
	48	5.73	60.70	23.41	3.81	7.35	4.73
CALFP	1	2.03	53.83	46.17	0.00	0.00	0.00
	3	3.78	53.10	45.95	0.20	0.02	0.73
	6	5.71	47.31	48.00	0.41	3.61	0.67
	12	8.70	39.92	49.89	3.11	4.54	2.54
	24	10.23	33.97	52.11	4.08	4.33	5.51
	48	11.12	33.96	50.14	4.19	6.08	5.63
COWP	1	1.09	31.49	13.62	54.89	0.00	0.00
	3	2.13	47.99	23.66	26.92	0.42	1.01
	6	2.90	53.38	28.18	15.38	2.03	1.03
	12	4.44	44.50	40.50	10.49	2.44	2.07
	24	5.39	38.91	44.60	8.51	3.29	4.69
	48	5.78	38.12	43.84	7.89	5.09	5.06
PAIRP	1	24.17	3.18	7.84	7.80	81.18	0.00
	3	32.68	20.26	26.36	5.66	45.30	2.42
	6	49.71	30.02	36.36	6.92	24.09	2.61
	12	78.00	32.79	45.65	4.08	13.45	4.03
	24	101.68	28.86	50.93	5.00	8.83	6.38
	48	111.00	29.48	48.91	5.30	9.84	6.47
BULLP	1	248.87	0.01	0.48	0.49	0.32	98.70
	3	261.02	0.21	1.21	5.93	1.23	91.42
	6	271.33	1.67	4.90	6.26	2.46	84.71
	12	303.19	7.49	10.10	10.06	3.16	69.19
	24	323.99	10.31	13.62	10.22	3.83	62.02
	48	329.46	11.03	14.95	10.24	4.29	59.49

[a]FATP = Slaughter steer price ($/cwt); CALFP = 500–600 lb. feeder steer price ($/cwt); COWP = utility cow price ($/cwt); PAIRP = cow-calf pairs price ($/pair); BULLP = purebred bull price ($/head); r = forecast horizon (months).

prices was largely explained by its own innovations at a lag length of one month. Thereafter, innovations in slaughter steer and feeder calf prices accounted for an increasingly larger portion of the forecast error variance, with feeder calf prices exerting the greatest influence.

Bull prices were nearly exogenous up to a one-month forecast horizon. Utility cow innovations exhibited the earliest influence on bull prices, followed quickly by feeder calf and then slaughter prices. Feeder calf price innovations accounted for the largest portion of forecast error variance in bull prices (other than bull price innovations themselves) after a twelve-month forecast horizon. Shocks in cow-calf pair prices accounted for a relatively small proportion of bull forecast error variance.

Impulse Response Functions

Changes in bull prices over a 36-month horizon from a single unit (one-standard-deviation) change in each price series were developed from the impulse response functions and are shown in Figures 1 and 2. Standard deviations were developed from the historical forecast errors of the vector autoregression.[1] The same triangularizations which were used in determining the forecast error variances were used here.

Figure 1 presents the cumulative response of bull price to one-standard-deviation shocks in slaughter steer and feeder calf prices. It took eight months before bull price started to trend upwards after the increase in slaughter steer prices. The shock in slaughter steer price exhibited its major effect on bull prices in months eight through fifteen. From the sixteenth through twenty-seventh month, there was only a minor marginal effect on bull prices, after which the bull price change trended back towards zero.

The positive increase in calf prices exhibited a small, but negative effect on bull prices during the first two months. Thereafter, the marginal response was positive until the twenty-eighth month, with the major increase coming between the eighth and sixteenth months. The lag between an increase in calf prices and bull prices may occur for two reasons. First, it may take a few months for commercial cattleman to change their expectations as to the price they will be receiving for calves sired by a newly acquired bull after an increase in calf prices occurs. Secondly, if the commercial producer desires to increase his breeding herd because of expected higher calf prices, there is a biological lag between the time these expectations are formed and the time extra bulls are needed to service retained cows and heifers.

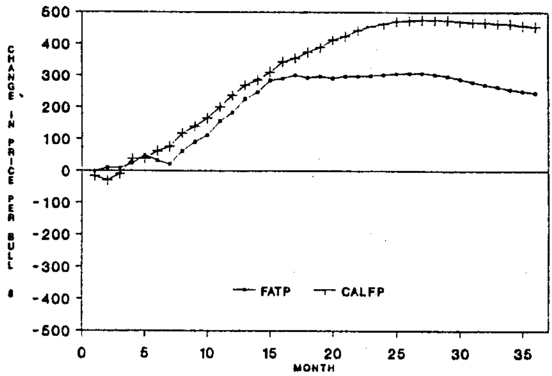

Figure 1. Bull Price Response to a One-Standard-Deviation Shock in Slaughter Steer (FATP) and Feeder Calf (CALFP) Prices.

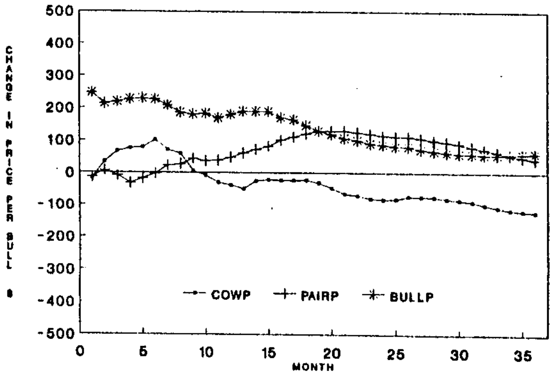

Figure 2. Bull Price Response to a One-Standard-Deviation Shock in Cow-Calf Pair (PAIR), Utility Cow (COWP), and Bull (BULLP) Prices.

Responses of bull prices to one-time shocks from utility cow prices, cow-calf pair prices, and bull prices are given in Figure 2. Bull prices exhibit a slightly oscillatory behavior after an initial increase in their own price, with the price change returning to zero in the long run.

A shock in utility cow prices had the most pronounced positive effect on bull prices of all the price series considered during the first seven months. The magnified response in bull price to an increase in utility cow price may be due to utility cow prices serving as a proxy for slaughter bull prices. Because service-age bulls are at least worth their value as slaughter bulls, an increase in the latter would also establish a new base price for purebred bulls. Also, because many cattlemen use the revenue from selling their old bulls to purchase new ones, an increase in slaughter bull prices would enable them to improve the genetic base of their herd by purchasing a younger bull, thereby increasing the demand for young service-age bulls. After the bull price peaks in the sixth month, the marginal response turns negative as the price series begins its oscillatory behavior towards equilibrium.

The bull price response to a shock in cow-calf pair price was negligible for several months. It was thought a priori that bull prices would respond rather quickly to an increase in cow-calf pairs because an increase in the latter would tend to favor holding breeding stock. The response in bull price to the shock in cow-calf pairs, though, mimics the response exhibited by a shock in calf prices; perhaps indicating cow-calf pairs were priced

[1]The mean and standard deviation, respectively, for each filtered series is CALFP = .182E-06, 2.41; FATP =.138E-06, 2.51; COWP = .250E-07, 1.30; PAIRP = −.335E-05, 28.79; and BULLP =.418E-05, 296.53.

based on the value of the calf and not so much the value of the cow for breeding purposes.

SUMMARY AND CONCLUSIONS

This study focused on the dynamic relationship which exists between the commercial cattle and purebred cattle markets using a vector autoregressive procedure. Results indicated that the purebred bull price series was nearly exogenous up to a three-month lag, while at lags of over 12 months, slaughter steer prices, calf prices, utility cow prices, and cow-calf pair prices accounted for approximately 40 percent of the bull price innovations.

Impulse response functions showed that purebred bull prices are influenced most quickly by an increase in utility cow prices (proxy for slaughter bull prices). This result conforms with the hypothesis that slaughter bull prices act as a price floor for purebred bulls and/or increase seed money (for purchasing new bulls) obtained from cull bulls. The largest overall response in purebred bull prices came from an increase in feeder calf prices, followed by slaughter steer prices. The positive response from the calf price shock was delayed until the third month, and the full effect of the increase in calf prices was not exhibited in increased bull prices for over two years. This is in agreement with the hypothesis that commercial cattlemen's expectations of future profits do not change instantaneously with increases in feeder calf or slaughter steer prices but are changed over a period of several months. This may suggest some validity to the complaint voiced by many purebred breeders that purebred bull prices respond more slowly than desired to an increase in calf prices. Bull prices responded to an increase in cow-calf pair prices in a fashion similar to, but smaller than, a shock in feeder calf prices. This indicated that the cow-calf price more closely reflected the value of calf prices rather than the expectations of breeding stock value as was hypothesized.

The delayed, even slightly negative, response of bull prices to an increase in feeder calf and cow-calf prices may also result from purebred producers being anxious to increase marketings when feeder calf prices first increase. This eagerness to take advantage of an upswing in the commercial cattle market, without an increase in demand for bulls, could create a stagnant bull market for a few months. While additional research needs to be conducted in this area, purebred producers should realize that expectations take time to formulate and bull marketing should be designed to take advantage of this (e.g., slightly delayed marketings after a commercial market price increase).

Results further indicate the existence of lagged relationships between fat cattle, utility cow, and feeder calf prices. Additional use of vector autoregression may be able to extend studies which have suggested slaughter cattle prices and various feeder cattle prices move together with little or no lag (Spreen and Shonkwiler; Franzman and Walker; Barksdale et al.).

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