Fabricated Cut Beef Prices as Leading Indicators of Fed Cattle Price

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Temporal relationships are investigated among fabricated cut prices, carcass value, and fed cattle prices. Also, linkages between fed cattle and wholesale beef prices are examined using vector autoregression (VAR) techniques. Results, using daily prices over the 1980–85 period, suggest that fabricated cut prices and cattle prices are related to the imputed carcass value, carcass quote, and fed cattle prices. In addition, three fabricated cuts dominate as leading indicators of fed cattle prices and of most fabricated cut prices. They are strip loin and bottom and top round prices. VAR models outperform the univariate and random-walk models in forecasting ability.

Key words: beef prices, cattle prices, forecast, leading indicators.

From a derived demand perspective, beef prices may be useful to infer future changes in fed cattle prices. Carcass quotes are no longer supported because of low volume and the increased occurrence of formula pricing (Ray). Estimates are that over 90% of all carcass trades are made by formula (Burke). This has resulted in a "thin" market for beef carcasses (Hayenga and Schrader). A thin market may result from low volume and a small proportion of negotiated and publicly reported trades (Hayenga).

A compelling alternative to the carcass price as a reference price for processed beef is the imputed carcass value (ICV) or the "boxed beef cut-out" price reported by the U.S. Department of Agriculture (USDA) Market News Service. The ICV is a weighted average price computed by the USDA based upon individual boxed beef prices.[1] In contrast to the low volume carcass market, most beef is sold as boxed beef. Typically, boxed standard beef cuts are priced individually through negotiation, rather than by formula. This leads to a popular belief among industry participants that the ICV is a more sensitive and accurate gauge of supply and demand conditions than is the carcass price (Fuller). However, temporal relationships may exist among the ICV, carcass price, and boxed beef price.

Some research has examined temporal relationships among vertically linked prices in a marketing channel (Bessler and Schrader; Schroeder and Hayenga; Shonkwiler and Lea). Others have examined the reasons for perceived quality problems in publicly reported data series for wholesale beef and fed cattle (Davis and Sporleder; Rhodes). These latter efforts address normative linkages among vertically linked prices without examining the potential for a price at one level to be used as a leading indicator of a price change at another level, while the former studies represent empirical studies using within-sample fits.

In this article we examine the use of boxed beef prices as leading indicators of fed cattle

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[1] Boxed beef is the process of cutting the carcass into primal or subprimal cuts, vacuum packaging each cut, and grouping them for sale, as demand requires. Boxed standard beef cuts are the most processed of all forms of boxed beef sales. USDA reports daily prices for 11 different primal cuts. This series is referred to throughout this article as boxed beef or fabricated cut prices.

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price. Temporal relationships among boxed beef cuts, carcass, and fed cattle prices of the cattle-wholesale beef marketing channel are examined. The potential of wholesale beef prices in forecasting daily fed cattle prices is empirically investigated. The dynamic aspects of the temporal relationships are estimated using vector autoregression techniques (Sims). Out-of-sample forecasting performance is offered as evidence supporting particular relationships found in the research.

The Theoretical Model

The theory of derived demand suggests that cattle prices are determined by beef prices. However, in the short run cattle supply factors do influence beef prices. These two features provide the foundation for the model developed and are used to investigate the temporal interaction of this segment of the marketing channel.

Static supply functions at each level of this segment are denoted as:

(1) $$Q_f^s = f_1(P_f, V),$$

(2) $$Q_c^s = f_2(P_c, W),$$

and

(3) $$Q_b^s = f_3(P_b, X),$$

where Q_f^s, Q_c^s, and Q_b^s are the quantities of fed cattle, carcasses, and boxed beef supplied, respectively, and P_f, P_c, and P_b are their corresponding prices. Also, V, W, and X are the supply shifters at each market level (such as feed grain costs, weather, transportation and processing costs).

Similarly, static demand functions for cattle and beef are:

(4) $$Q_f^d = f_4(P_f, P_c, P_b, Z),$$

(5) $$Q_c^d = f_5(P_f, P_c, P_b, Z),$$

and

(6) $$Q_b^d = f_6(P_f, P_c, P_b, Z),$$

where Q_f^d, Q_c^d, Q_b^d, are the quantities demanded of fed cattle, carcasses, and boxed beef, respectively. The quantity demanded is a function of own price, the price of output from the production process at the selected level of the marketing channel, and other demand shifters denoted by Z (such as income, population, prices of substitutes and complements, etc.). Equilibrium prices can be determined by equating the supply and demand at each level. This results in the reduced-form relationship given as the following vector equation:

(7) $$(P_f, P_c, P_b)' = f(\Theta),$$

where (Θ) is a vector of the supply and demand shifters. The reduced-form relations are the relevant ones for analyzing price adjustments associated with fluctuating market conditions. This reduced form assumes price adjustments are instantaneous.[2]

However, price adjustments are not instantaneous. Time elapses before the information concerning cattle supplies or wholesale beef demand has a full impact on the other levels. This is due in part to the fixed proportions of beef cuts from fed cattle and their dressed carcasses. Equation (7) must be expanded to encompass temporal price adjustment. Expectations on price adjustments generally will introduce lags of relevant time-series information into the dynamic specification of price determination (Nerlove, Grether, and Carvalho, p. 360).

The time element can be introduced into the reduced-form equation by dating prices and quantities. So current prices reflect current and past information at all levels of the marketing chain:

(8) $$(P_{ft}, P_{ct}, P_{bt})' = g(\Theta_t, \Theta_{t-1}, \ldots, \Theta_{t-q}),$$

where q is the maximum length of time required for prices to respond to an information shock. That is, prices are related to current and past supply and demand factors at all levels of the subsector.

A difficulty in attempting to estimate the parameters of equations (1)–(6) or in estimating the structural parameters which generate equation (8) is that the demand and supply vector contains variables difficult to measure, especially for short periods such as days. Further, if agents form expectations using full information sets (that is, both demand side and supply side variables enter the expectations models of industry participants), then the explicit structural coefficients will not be identifiable (Sims; Liu). Accordingly, the structural approach is not practical for much empirical work. An alternative is to consider that the vector P is generated by a stochastic process which can be identified and estimated.

[2] This model is similar to a model developed by Brorsen, Chavas, and Grant for investigating temporal rice price relationships.

Methods

Daily USDA wholesale beef quotations for central U.S. f.o.b. were analyzed for the period 1980 through 1985 (USDA, *Wholesale Meat Quotations*). Fed cattle prices were daily Texas-Oklahoma direct sales for choice 900–1,100-pound steers (USDA, *Livestock, Meat, and Wool Market News*).

Temporal Relationships

Temporal relationships among the set of price quotes for beef cuts were studied using the VAR procedure outlined in Hsiao. Briefly, this procedure was used to determine the lagged response among the set of theoretically related variables. The first four years of data (1980–83) were used to fit the models; the last two years (1984–85) were used for out-of-sample forecast evaluation. The emphasis of the analysis is ultimately on the predictive information available in past quotes, as judged by squared-error loss. Earlier work (Kling and Bessler; Bessler) suggests that this procedure works well (yields "good" predictions) for modeling dynamic relationships among variables.[3]

Empirical relationships among deseasonalized data were studied, using the FPE-loss metric (a weighted squared-error loss metric) conditional on a prior ordering of importance of each variable in the representation of each other variable. Two seasons were considered—summer (May through September) and winter (October through April).[4] The data were deseasonalized using ordinary least squares regression of the daily price on an intercept and single (summer season) dummy variable. Results of this regression are given in table 1. Seasonality was statistically significant at the 95% confidence level for fed cattle price, ICV price, and all meat cuts except bottom sirloin butts.

The representation of each deseasonalized price series is determined by searching over past lags of each series itself, as well as past lags of each other series. The model yielding the lowest final prediction error (FPE) measure is selected as the autoregressive representation of the particular time series. The FPE statistics are the residual variances adjusted to account for the number of regressors and observations in each regression:

$$FPE_{m,n} = (T + m + n)/(T - m - n) \sum_{t=m+n}^{T} [(A_t - F_t)^2/T], \quad (9)$$

where m lags of the dependent variable and n lags of the independent variable are used to determine the current level of the dependent variable. The variable A equals the actual price and F is the forecast value from historical data.

The univariate model on each price series was studied first. The univariate model was determined by searching for the minimum FPE over successive ordinary least squares regressions of lags of order 1 through 20. Twenty days was chosen as the maximum time boxed beef typically would be held in storage.

The multivariate model was determined by adding, in order of importance to the univariate model, each additional variable. The order of importance was determined judg-

Table 1. Seasonality Factors in Fed Cattle and Boxed Beef Prices, Simple Linear Regression, Daily Price, 1980–83

Dependent Variable[a]	Intercept	Summer Influence	t^b
Fed Cattle	65.43	−0.75	−3.09**
Imputed Carcass Value	103.84	1.12	3.10**
Armbone Chuck	107.33	−3.22	−6.13**
Rib Roast	227.28	7.65	3.15**
Brisket	107.93	−8.89	−13.68**
Top Round	158.51	1.81	2.31**
Bottom Round	142.21	−11.73	−17.74**
Knuckle	151.62	−4.92	−9.23**
Striploin	261.62	28.67	16.29**
Top Sirloin Butt	193.80	19.05	14.27**
Full Tenderloin	318.03	3.08	2.07*
50% Trim	51.81	2.15	3.52**

Note: Single asterisk indicates significance at the 95% confidence level; double asterisk indicates significance at the 99% confidence level.

[a] Carcass prices and bottom sirloin butts showed no significant seasonal influence; thus, no statistics are reported for their seasonal factors.

[b] t-statistic is on the coefficient associated with the summer influence variable which is estimated with ordinary least squares regression.

[3] See Judge et al. (p. 119) on the distinction between unbiased estimation and minimum mean-squared error loss.

[4] Two reviewers suggested that four seasons should have been considered. Our interest was not to test particular hypotheses but to build simple (parsimonious) dynamic models. It was the authors' subjective judgment that two seasons would account for major seasonal regularities. Of course, the relevant test is the out-of-sample forecast results. Our data are available to readers if such a comparison is of interest.

mentally by the authors and is summarized in table 2. Hsiao indicates that the order in which variables are introduced into the search can possibly affect the final model. By listing the ordering used in this study, other researchers can, if they disagree with the ordering used, study alternatives they may wish to investigate. Each variable was evaluated in the regression equation one at a time, at successive lag lengths. If a variable at one of the 20 lags yielded a smaller FPE statistic than that generated by the univariate model, it was included in the multivariate model at the lag length. This process was done for 20 lags of all the variables, searching for successively smaller values of FPE. Once all other series were considered as right-hand-side variables in a particular equation, the lags of variables determined last were held fixed and lags on variables determined earlier were researched to ensure that their specification did not change with the inclusion of the introduced variables. If a change did occur, the lowest FPE-model specification was used in subsequent analysis. The final model was estimated using seemingly unrelated regression (SUR) to account for possible contemporaneous error correlations in the 12 alternative meat price equations.

Forecast Evaluation

An out-of-sample period, 1984 and 1985, was chosen to evaluate the predictive performance of these models. The SUR model was used to generate recursive forecasts over the evaluation period. The model was updated each period using the standard Kalman-filter technique (Doan and Litterman). That is, the forecast analysis is recursive through the evaluation period. Each data point generated a new forecasting model (through the Kalman filter) and a new set of forecasts for each date in the forecast horizon. Forecasts for one- to 10-day horizons were calculated using standard chain rule of forecasting methods (Sargent, p. 268). That is, forecasted values for one-step-ahead forecasts are used in the vector autoregression to make forecasts for two-steps-ahead horizons, etc.

Performances of the models were evaluated relative to random-walk forecasts. A random-walk series means that changes cannot be predicted from past changes. That is, changes in price are equal to random disturbances or $P_t = P_{t-1} + e_t$. A model which does not improve over the random-walk forecast is certainly not to be taken seriously as a useful description of price interrelationships.

Results

Results are presented in terms of the leading indicator models and forecast evaluations.

Leading Indicators and Dominant Cuts

The univariate representation of cattle prices is a second-order autoregressive process, while carcass quotes and ICV are generated by third-order models (table 3). The ICV appears to reflect market conditions more quickly than any individual cut. That is, ICV is generated by a smaller order univariate model than the other cuts. This may be attributable, in part, to the way the ICV is calculated daily by the USDA. The ICV is calculated by USDA with individual boxed beef prices which qualitatively reflect market conditions. The ICV thus reflects the market reporter's understanding of market conditions. This represents additional information embedded in the ICV price which apparently is not reflected in individual boxed beef prices.[5]

Cattle price, carcass price, and ICV price entered all multivariate specifications. Cattle prices and carcass quotes typically had low ordered lags while the ICV had longer ordered lags (except on armbone chuck). This is due partly to the ICV reflecting a weighted influence of all other cuts and products. In the case of all of the individual boxed beef cuts, the ICV was the first price to enter the multivariate specification. In 10 out of 11 cases, a minimum FPE statistic occurred at a lag of 15 days on the ICV. The consistent 15-day lag suggests that there may be trade customs and storage arrangements which influence individual boxed beef cut prices.

The dominant cuts are those which entered the specification in addition to the ICV and lags of own prices in any equation. Three cuts, striploins, bottom round, and top round, were

[5] The market reporter records a price range for every cut traded. However, the reporter can determine if the majority of the trades were at either the high or low end of this price range. Therefore, the reporter can calculate a weighted average price for each cut. This, in turn, is used by USDA to estimate the ICV for that day.

Table 2. Ranking of the Order of Importance of Multivariate Specifications of Each Price Series

Rank	*CAT*[a]	*CAR*	*ICV*	*ARB*	*RIB*	*BRT*	*TRD*	*BRD*	*KNL*
1	*CAR*	*ICV*	*CAT*	*ICV*	*ICV*	*TRIM*	*ICV*	*ICV*	*ICV*
2	*ICV*	*CAT*	*CAR*	*CAR*	*CAR*	*KNL*	*CAR*	*CAR*	*CAR*
3	*ARB*	*FTLN*	*FTLN*	*CAT*	*CAT*	*BRD*	*CAT*	*CAT*	*CAT*
4	*RIB*	*STLN*	*STLN*	*BRT*	*FTLN*	*ARB*	*FTLN*	*KNL*	*BRD*
5	*STLN*	*RIB*	*RIB*	*BRD*	*STLN*	*FTLN*	*STLN*	*ARB*	*ARB*
6	*TRD*	*TSB*	*TSB*	*KNL*	*TSB*	*STLN*	*RIB*	*BRT*	*BRT*
7	*TRIM*	*TRD*	*TRD*	*FTLN*	*TRD*	*RIB*	*TSB*	*FTLN*	*FTLN*
8	*TSB*	*KNL*	*KNL*	*STLN*	*BSB*	*TSB*	*BSB*	*STLN*	*STLN*
9	*FTLN*	*BRD*	*BRD*	*RIB*	*TRIM*	*TRD*	*TRIM*	*RIB*	*RIB*
10	*KNL*	*ARB*	*ARB*	*TSB*	*KNL*	*BSB*	*KNL*	*TSB*	*TSB*
11	*BRD*	*BRT*	*BRT*	*TRD*	*BRD*	*ICV*	*BRD*	*TRD*	*TRD*
12	*BRT*	*BSB*	*BSB*	*BSB*	*ARB*	*CAR*	*ARB*	*BSB*	*BSB*
13	*BSB*	*TRIM*	*TRIM*	*TRIM*	*BRT*	*CAT*	*TRIM*	*TRIM*	*TRIM*

Note: For a discussion on the importance of rankings, see Hsiao.
[a] *CAT* = Fed Cattle, *CAR* = Carcass, *ICV* = Imputed Carcass Value, *ARB* = Armbone Chuck, *RIB* = Rib Roast, *STLN* = Striploin, *TRD* = Top Round, *TRIM* = 50% Trim, *TSB* = Top Sirlon Butt, *FTLN* = Full Tenderloin, *KNL* = Knuckle, *BRD* = Bottom Round, *BRT* = Brisket, *BSB* = Bottom Sirloin Butt.

statistically leading indicators. For example, changes in today's striploin price indicate price changes tomorrow for fed cattle, bottom rounds, rib roasts, briskets, and ICV.

Forecast Evaluation

The analysis indicates that there are leading indicators among certain fabricated cut prices and the fed cattle price (table 4). Once identified, these relationships may be examined with respect to their forecasting ability. Forecasts up to two weeks (10 days) ahead are evaluated at each date over the evaluation period (1984 and 1985 daily price quotes). In the case of briskets and rib roasts, a random-walk forecast is a better predictor than either the multivariate or univariate models (note the zeros in both the univariate and multivariate columns and the *RIB* and *BRT* rows of table 4). Percent forecast improvement over the random walk was used as an evaluation criterion.

Table 3. Lead-Lag Relationships among Fabricated Cut, Carcass, and Fed Cattle Prices with Number of Days Indicated, Daily, 1980-83

Dependent Variable	*CAT*	*CAR*	*ICV*	*ARB*	*RIB*	*BRT*	*TRD*	*BRD*	*KNL*	*STLN*	*TSB*	*BSB*	*FTLN*	*TRIM*
	lags[a]													
CAT	2	2	7							1				
CAR	3	3	14				1	3						
ICV	10	2	3					3		1				
ARB	3	9	1	10										
RIB	3	1	15		13									
BRT	3	1	15			5				1				
TRD	1	1	15				4							
BRD	3	1	15					2		1				
KNL	3	1	15				1	5						
STLN	3	1	15							4				
TSB	3	1	15				1				9			
BSB	3	1	15									8		
FTLN	3	1	15				1						7	
TRIM	3	1	15				1							6

Note: For definitions of the variables, see note to table 2.
[a] The number of days is the order of the lags which entered the multivariate model. For example, cattle prices (dependent variable) are generated by two lags of cattle prices, two lags of carcass quotes, seven lags of imputed carcass value, and one lag of striploin price.

Table 2. Extended

STLN	*TSB*	*BSB*	*FTLN*	*TRIM*
ICV	*ICV*	*ICV*	*ICV*	*ICV*
CAR	*CAR*	*CAR*	*CAR*	*CAR*
CAT	*CAT*	*CAT*	*CAT*	*CAT*
FTLN	*FTLN*	*FTLN*	*STLN*	*BRT*
RIB	*STLN*	*STLN*	*RIB*	*ARB*
TSB	*RIB*	*RIB*	*TSB*	*FTLN*
TRD	*TRD*	*TSB*	*TRD*	*STLN*
BSB	*BSB*	*TRD*	*BSB*	*RIB*
TRIM	*TRIM*	*TRIM*	*KNL*	*TSB*
KNL	*KNL*	*KNL*	*BRD*	*TRD*
BRD	*BRD*	*BRD*	*ARB*	*BSB*
ARB	*ARB*	*ARB*	*BRT*	*KNL*
BRT	*BRT*	*BRT*	*TRIM*	*BRD*

This is the difference between unity and the Theil-U (Doan and Litterman).

The random-walk model was superior over the first forecast week for top sirloin butt, full tenderloin, and 50% trim. Over the latter part of the 10-day period, the multivariate model predicted better for 50% trim and full tenderloin and the univariate model predicted better for top sirloin butt. These mixed results may arise because there is less within-week variation in prices than among weeks. The random-walk model appears better when there is minimal price variation. The more complicated models are needed to more fully explain variation across weeks.

The multivariate models predicted carcass, ICV, bottom and top round, knuckle, and striploin prices consistently better over the 10-day forecasting period than did the other two models. Multivariate models showed an average improvement of 56% in forecasting ability over the random walk and 14% over the univariate model. The greatest forecast improvement over the random walk was in the multivariate models for striploin and bottom sirloin butt.

Table 4. Total Percent Forecast Improvement over Random Walk for a 10-day Forecast Period, 1984-85

	Univariate		Multivariate	
	Day(s) Forecast Period[a]	Percent Improvement[b]	Day(s) Forecast Period[a]	Percent Improvement[b]
CAT	1–10	7	1–10	47
CAR	1–10	0	1–3	8
ICV	1–10	37	1–10	56
BRT	1–10	0	1–10	0
TRD	1–10	0	1–4	9
ARB	1–10	41	1–10	41
RIB	1–10	0	1–10	0
BRD	1–10	0	1–7	13
KNL	1–10	50	1–10	72
STLN	1–10	124	1–10	132
TSB	1–3	5	2	3
	4	0	3–5	0
	5–10	23	6–10	22
BSB	1–10	117	1–10	118
FTLN	2	0	1–2	0
	3–10	18	3–10	55
TRIM	1–10	0	1–5	0
			6–10	44

Note: For definitions of the variables, see note to table 2.
[a] The days of the 10-day forecast period for which the improvement applies.
[b] Total percent improvement over the forecast period.

Summary and Conclusions

Temporal relationships at two pricing levels in the cattle-beef marketing channel were analyzed. Vector autoregression was used to identify prices which are related through time and to estimate the length of that relationship. As expected, the greatest correlation of price was to its own past prices. In addition, previous fed cattle prices, carcass quotes, and ICV were directly related to all prices forecasted. The middle cuts--striploins and top and bottom rounds—also entered the multivariate specifications for several prices, indicating their dominance in beef pricing.

The analysis suggests that striploin price is a leading indicator of fed cattle price among all the other fabricated cut prices examined. This "middle cut" appears to lead fed cattle price by one day, indicating that at least the direction of change in tomorrow's fed cattle price would be inferred from the direction of change in today's striploin price. In addition, fed cattle price tends to reflect the composite ICV for up to seven days prior but only two days prior for fed cattle price and carcass quote.

The forecasts of the multivariate models generally were superior to the univariate and random-walk models. The random-walk model performed the best for two of the 14 fabricated cut prices—briskets and rib roast prices. The multivariate models outperformed the univariate models in all other cases. This suggests useful forecasting relationships among fabricated cut beef price and fed cattle price.

These relationships, identified and estimated, can be useful in predicting daily prices for cattle and many beef cut prices, rather than simply relying upon yesterday's price as an estimate of today's price.

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