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U.S. Feeder Cattle Prices: Effects of Finance and Risk, Cow-Calf and Feedlot Technologies, and Mexican Feeder Imports

John M. Marsh

Analysis of U.S. feeder steer prices normally includes fed cattle prices and feed grain costs. An expanded econometric model which investigates finance cost, profit risk, hay cost, technology, and Mexican feeder cattle import shares is estimated. Results indicate statistical significance of nearly all variables. The increase in feeder import shares contributed to \$0.60/cwt of the \$24.48/cwt decline in real feeder price from 1980–1999. Improved technology in producing feeder calves has reduced feeder prices more substantially, by \$4.86/cwt from 1980–1999. Increased feedlot technology through cost savings has increased feeder price. Feedlot risk management and macro-economic policies affecting the U.S. prime interest rate could continue to affect feeder prices.

Key words: feeder cattle, import shares, interest, price impacts, risk, technology

Introduction

Beef producers determine their breeding herd size by many factors, with one critical factor being expected price of feeder cattle (Foster and Burt; Jarvis; Marsh 1999; Rosen, Murphy, and Scheinkman; Rucker, Burt, and LaFrance; Schmitz). Similarly, feeder prices largely influence the decisions of beef operators purchasing feeder cattle for backgrounding or finishing programs (Anderson and Trapp; Shonkwiler and Hinckley). With feeder cattle prices playing crucial roles in production and marketing decisions, factors determining expected levels of these prices are critical information.

The purpose of this article is to develop a derived demand and primary supply model of the U.S. feeder cattle sector and econometrically estimate the equilibrium U.S. feeder cattle price. Three new aspects are emphasized here: (a) quantifying domestic information excluded from previous research, (b) evaluating the effects of Mexican feeder cattle import shares, and (c) assessing the effects of cow-calf and feedlot technologies. Cow-calf technology in the current analysis refers mainly to genetics and health and nutrition factors affecting weaning weights and calving percentages. Feedlot technology primarily reflects management practices, health and nutrition, mechanization, etc. influencing efficiency of weight gains in cattle finishing.

Structural modeling in the beef sector typically has focused on retail, slaughter, and marketing margin levels (Arzac and Wilkinson; Azzam and Anderson; Brester and

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Wohlgenant; Dunn and Heien; Eales; Freebairn and Rausser; Holloway; Koontz and Garcia; Marsh 1988; Moschini and Meilke; Wohlgenant). Several studies have modeled the feeder cattle sector (Anderson and Trapp; Brester and Marsh 1983; Buccola; Shonkwiler and Hinckley), but, with the exception of Anderson and Trapp, previous work is dated. In addition, analyses examining demand and supply behavior have often been limited to factors in the slaughter cattle and feed grain markets, ignoring other market influences.

Normally, feeder cattle prices respond to changes in slaughter cattle prices and feed costs (Anderson and Trapp; Buccola; Shonkwiler and Hinckley). However, it is hypothesized that decision making related to firm behavior in producing and adding value to feeder cattle behooves the assessment of other factors which affect feeder prices. Variables excluded from previous econometric work but included in this model are finance costs, profit risk, cow-calf and feedlot technologies, and U.S. imports of feeder cattle. Their importance reflects changing price discovery and marketing programs, breeding and nutrition programs, cattle finishing capacity, and production and marketing efficiencies. Results of this empirical study provide important information to cow-calf producers, backgrounders, and cattle finishers whose purchase or sale decisions depend on future expectations of feeder calf and yearling prices.

Background Information

Although factors in the fed cattle market and feed grain market normally play important roles in determining feeder cattle demand and prices, other economic factors warrant attention. Because of the finance requirements of feeder cattle production, retained ownership, and cattle finishing (Duncan et al.), the opportunity cost of capital is likely to be important in affecting feeder prices. Ignoring interest costs in models of feeder demand (price) could result in specification errors due to their cost importance and market volatility. For example, in 1998, interest cost in Great Plains custom finishing averaged about 17% of total cost of gain [U.S. Department of Agriculture (USDA), *LDP* report], and from 1970–1998, the standard deviation of the prime interest rate was about 33% of its mean value (Congress of the U.S., Council of Economic Advisors).

Profitability risk in cattle feeding has also largely been ignored in models of feeder prices. However, risk factors in beef margin analyses have been addressed (Holt; Schroeter and Azzam). Profitability risk in cattle finishing, which affects feeder prices, can be managed through futures hedging of feed grains and fed cattle, yet basis volatility is significant [Livestock Marketing Information Center (LMIC)]. Production risks related to weight gain and the inherent seasonality of fed cattle prices can also make hedging fed cattle difficult. Consequently, profitability risk in cattle finishing persists. From 1970 to 1998, the standard deviation of the ratio of fed steer price to corn price (proxy for feedlot profitability) was about 24% of its mean value.

Technological changes in the beef sector, often associated with meat packing and retailing (Nelson and Hahn), have also occurred in feeder cattle production and cattle finishing. Feeder production technology has principally been concerned with breeding genetics and management of health and nutrition which have increased calving rates and calf weaning weights; finishing technology has involved scale economies and feeding efficiency which have reduced capital costs per head and cost per pound of gain (Boggs and Merkel; Duncan et al.; Kuchler and McClelland). One measure of cow-calf technology

would be beef cow productivity, or U.S. steer and heifer carcass pounds produced per cow, adjusted for live cattle imports (Marsh 1999). Similarly, one measure of feedlot technology would be growth in large capacity feedlots, often associated with technological change in finishing (Kuchler and McClelland).¹

In recent years, U.S. imports of live cattle have been controversial, particularly fed cattle imports from Canada (Brester and Marsh 1999). Likewise, U.S. imports of feeder cattle from Mexico have concerned producers (Peel), particularly in the 1992–1995 period with record levels of Mexican imports and declining real prices. Feeder cattle imports are largely a function of size of Mexican cattle inventories, weather in Mexico, U.S. cattle prices, and excess capacity in U.S. cattle finishing (Peel). USDA data show feeder cattle imports from Mexico have increased substantially, i.e., from 196.1 thousand head in 1975 to a peak of nearly 1.7 million head in 1995 (USDA 2001). Imports of Canadian feeder cattle are relatively small, but there is also a lack of consistent data for this cattle class. Import market share, defined as Mexican feeder cattle imports as a percentage of total U.S. feeder supplies, permits evaluating the foreign influence on U.S. feeder price.

Model Framework

Estimating price behavior in the U.S. feeder cattle sector requires developing the structure of derived demand and primary supply. For expediency, inverse demand and supply functions are specified in order to derive the arguments of equilibrium feeder price. Inverse structural demand and supply is commonly used in agricultural commodity models, particularly if production quantities are considered predetermined and market prices are endogenous (Dunn and Heien; Eales; Huang). In the current model, market participants in the feeder sector include producers of feeder cattle (the suppliers, or cow-calf and yearling operators) and cattle finishers (the demanders, or operators finishing steers and heifers on grain concentrate rations). Competitive markets are assumed; i.e., individual cow-calf producers face perfectly elastic demands and individual cattle finishers face perfectly elastic supplies.

The following equations describe the theoretical structure of the feeder cattle sector:

- (1) $P_f^d = f_1(Q_f^d, P_s, P_c, I, R, T_f)$ (inverse demand),
- (2) $P_f^s = f_2(Q_f^s, P_h, I, T_c)$ (inverse supply),
- (3) $Q_f^d = Q_f^s \equiv Q_f$ (market clearing),
- (4) $P_f^d = P_f^s = P_f$ (market clearing).

The dependent variables, P_f^d and P_f^s , are respective demand and supply prices of medium No. 1 feeder steers, 750–800 pounds, Oklahoma City (dollars/cwt); Q_f^d and Q_f^s are

¹ An ideal measure of cow-calf productivity would be calf weaning weights. However, consistent time-series data on an aggregate basis are not published. Consequently, the calculation of output per breeding cow (employed in this study) uses steer and heifer dressed weights which reflect breeding genetics. Likewise, an ideal measure of finishing technology would be feeding efficiency such as pounds of grain to yield one pound of weight gain, but these time-series data are also lacking. Therefore, growth in large feedlots is assumed to proxy increased finishing technology due to factors such as scale economies, feed processing, and nutrition management.

respective total quantities demanded and supplied of U.S. feeder cattle—with *total* consisting of one-year lagged U.S. calf crop and current imports of Mexican feeder cattle (million head); P_s is price of Choice 2–4, 1,100–1,300 pounds, U.S. slaughter steers, Nebraska direct (dollars/cwt); P_c is price of No. 2 yellow corn, Central Illinois (dollars/bushel); P_h is U.S. average price of mixed grass and alfalfa hay (dollars/ton); I is U.S. prime interest rate (percent); R is feedlot profitability risk, given as a two-year moving average of the ratio of U.S. slaughter steer price to U.S. corn price (sum of the ratios lagged one and two periods divided by 2.0); T_f is technology in cattle finishing, proxied by total fed cattle marketed from large feedlots with more than 32,000 head divided by the number of these feedlots (in the 13 states of AZ, CA, CO, ID, IL, IA, KS, MN, NE, OK, SD, TX, and WA); and T_c is technology at the cow-calf production level, proxied by U.S. beef cow productivity.

Productivity is defined as: $[(\text{Steer Slaughter} \times \text{Average Dressed Weight of Steers} + \text{Heifer Slaughter} \times \text{Average Dressed Weight of Heifers}) - (\text{Canadian Fed Cattle Imports} \times \text{Average Dressed Weight of Steers} + \text{Mexican Feeder Cattle Imports} \times \text{Average Dressed Weight of Heifers})] \div (\text{U.S. Beef Cow Inventories} \times 0.95)$.² The multiplication factor of 0.95 is used since it is assumed 95% of January 1 beef cow inventories will calve. Because USDA estimates of commercial steer and heifer slaughter include cattle imports, estimated imports (carcass weight) from Canada and Mexico are necessarily subtracted to yield steer and heifer carcass pounds produced from the U.S. breeding herd. Light feeders are imported from Mexico, and value added primarily occurs in U.S. feedlots.

Equation (1) represents the input demand price for feeder cattle in the 700–800 pound weight range by domestic cattle finishers. Demand price depends on feeder quantities demanded (Q_f^d), output price (P_s), input costs (P_c , I), profitability risk (R), and feedlot technology (T_f). Feeder quantities demanded are aggregated for domestic feeders and imported feeders. It is assumed that changes in import quantities of Mexican feeders will affect U.S. feeder price no differently than changes in quantities of U.S.-born feeders. Feeder cattle imports as a percentage of total U.S. feeder supplies are used to evaluate the foreign impact on price.³ The expected impact of Q_f^d on feeder price is negative. Output price of slaughter steers (P_s) is expected to positively affect feeder price, as higher slaughter prices increase feedlot profitability and the demand for feeders. Similarly, the input costs of corn (feed price) and capital (interest rate) are expected to negatively affect feeder price, as higher corn prices or interest rates decrease feedlot profitability and feeder cattle demand.

Profit risk (R), defined as a two-year moving average, represents volatility in cattle finishing profits (Marsh 1999). Moving-average variables are often used to measure the effects of risk in regression analysis (Brester and Musick; Hooper and Kohlhausen).

² Although feeder imports from Mexico are primarily light steers, average dressed weights of heifers (rather than steers) were used in calculating total carcass weight of finished Mexican cattle. Genetics, lighter placement weights, and about 25% of imports being spayed heifers may indicate average dressed weights of finished Mexican feeders are close to the U.S. heifer average, although arguments may support it either way.

³ It might be argued that Mexican feeder imports are not identical quality as U.S.-born and raised feeders. However, quality of the U.S. calf crop, the major component of Q_f , is also heterogeneous. Therefore, the addition of Mexican feeders to U.S. feeder cattle inventories (which is a small percentage) is not expected to change the quality distribution of Q_f . Based on this assumption, feeder cattle imports are not specified as a separate regressor in equation (5). In this structural model, import shares are assumed to be predetermined—i.e., *causes* of changes in U.S. feeder imports are not quantified; the model requires only that exogenous changes have occurred and that import shares imply a feeder quantity impact on price.

Assuming cattle finishers are risk averse, an increase in profitability risk is expected to shift derived feeder demand to the left, hence reducing feeder price. Finishing technology (T_f), represented by growth in marketings per large feedlot ($\geq 32,000$ head), proxies unit cost changes that would shift derived demand for feeders. Under competitive conditions, an increase in productivity due to technology would increase feeder price as cost savings are passed on to feeder producers.

Equation (2), or inverse supply, represents the U.S. supply price of feeder cattle. Supply price (P_f^s) depends on quantity of feeder cattle supplied (Q_f^s), input costs of interest (I) and hay (P_h), and ranch-level technology (T_c).⁴ Hay prices in many areas of the U.S. are relevant costs in maintaining beef cow herds and retaining ownership of calves (Rucker, Burt, and LaFrance). Hay prices may also reflect weather and forage range conditions. For example, increased hay costs would be commensurate with poor pasture and forage conditions caused by inadequate rainfall, which, with lagged adjustments, could affect feeder supplies. Interest rate or the cost of capital could affect expansion or contraction of cow herds, and hence quantities of feeders produced. From a production standpoint, increases in the input prices of capital and hay would shift the supply curve of feeder cattle to the left. Technology at the cow-calf level, which increases weaning weights and reduces unit costs, would theoretically shift the supply curve of feeders to the right, decreasing feeder price.

Empirical Model and Estimation

Structural demand and supply equations (1) and (2) and market-clearing price and quantity equations (3) and (4) are used to solve for equilibrium feeder prices. Because of production lags caused by biological growth, feeder supplies are assumed predetermined. Substituting equilibrium quantity and price variables, Q_f and P_f , from respective equations (3) and (4) into equations (1) and (2) and solving, gives:

$$(5) \quad P_f = g(Q_f, P_s, P_c, P_h, I, R, T_f, T_c, \mu).$$

Equation (5) describes the demand-supply arguments expected to determine the behavior of equilibrium feeder cattle prices. A stochastic error term (μ) with assumed classical properties is appended. The equation appears as a reduced form, with the expected marginal impact of each variable consistent with its described structural impact. Because interest rate appears in both the demand and supply equations, the sign of its net effect is indeterminate.

Although feeder cattle supplies are assumed predetermined, joint dependency was tested in equation (5) due to specifying slaughter steer price as a regressor. Shifts in the dependent variable of feeder steer price (an input cost in cattle finishing) could be transmitted to the cattle finisher's output price. A Hausman specification test for slaughter

⁴ One reviewer raised a valid point concerning feeder cattle supplies. Conceptually they should be represented by USDA estimates of feeder cattle supplies (outside feedlots) rather than lagged calf crop because the latter may fail to account for stocker industry impacts of timing of feeder cattle supplies and breeding heifer retention. However, the USDA only publishes these feeder supply data back to 1979, and analysts indicate these estimates are suspect due to classification changes over time. Additionally, the estimates provide no information about the market share of Mexican feeder imports. Consequently, lagged calf crop and Mexican imports are used in this study to represent potential feeder cattle supplies that could enter feedlots within the year. This variable could overstate the feeder supply impacts in the empirical price model.

price was confirming since the null hypothesis of no simultaneous equation bias was rejected at the $\alpha = .05$ significance level.⁵

Other tests were conducted on the model. In summary, they include the following: (a) the Jarque-Bera test failed to reject the null hypothesis of normally distributed residuals, (b) White's test failed to reject the null hypothesis of homoskedastic errors, (c) the Durbin-Watson test indicated a negative AR(1) error structure, and (d) results of the Ramsey RESET test failed to reject the null hypothesis of a correctly specified equation. Using EViews 3.1 software, iterative two-stage least squares (2SLS) with an AR(1) error correction was the estimator employed.⁶ The model variables are assumed to enter equation (5) multiplicatively; therefore, double-log transformations are used in the estimation.

Dynamics

The underlying demand and supply structure of equation (5) may be dynamic, characterized by distributed lags. The dynamics are based on expectations of buyers and sellers as well as biological and technological factors that produce lag adjustments in cattle demand and supply prices (Marsh 1988; Rucker, Burt, and LaFrance). In pre-test estimation, the equation was specified with contemporaneous and first-order lags of the right-hand-side variables (except profitability risk), a first-order lag on the dependent variable, and an AR(1) error term. This structure approximated a Koyck or geometric distributed lag model (Pindyck and Rubinfeld). Based on a significance level of $\alpha = .10$, the Koyck term was omitted but the $t - 1$ lags were retained for cow-calf technology, hay price, and interest rate. Period t was omitted for these variables. Period t was retained for corn price, slaughter price, feeder quantities, and feedlot technology, while the $t - 1$ lags were omitted. This parsimonious lag structure constituted the empirical model to be estimated.

Data

Annual data from 1970 through 1999 are used to estimate the model. All price variables and the interest rate are expressed in real terms, deflated by the Producer Price Index (PPI, 1982 = 100). Price variables (feeder, slaughter, and corn), U.S. calf crop, Mexican feeder imports, and variables used in constructing beef cow productivity were obtained from the USDA's *Red Meats Yearbook* (on disc), the USDA's *Livestock, Dairy, and Poultry Situation and Outlook (LDP)* reports, and the Livestock Marketing Information Center (LMIC). Data on feedlot marketings and number of feedlots (13 states, $\geq 32,000$ head) were also obtained from the LMIC. Hay price was taken from the USDA's *Agricultural*

⁵ For confirmation of its exogeneity, the Hausman specification test was applied to U.S. feeder cattle supplies (Q_f) because of the feeder import component. The result was failure to reject the null hypothesis of no simultaneity at the $\alpha = .05$ level of significance. All equation variables were also tested for nonstationarity by the augmented Dickey-Fuller (ADF) unit root test. The null hypothesis of unit roots could not be rejected for any variable. The ADF test of the equation residuals found a cointegrated relationship; however, DeJong et al. argue these tests have low power in small samples. Furthermore, Johnston and DiNardo (p. 317) demonstrate that if a model contains simultaneous relationships, nonstationarity and cointegration are not of concern and traditional simultaneous estimation methods are appropriate. As a result, equation (5) is estimated in data-level form.

⁶ The instruments used for 2SLS were the exogenous variables of the equation plus external variables of real beef by-product value, wholesale quantities of pork and poultry, real labor costs in food processing, and real consumer expenditures.

Statistics. The PPI and prime interest rate were derived from the *Economic Report of the President* (Congress of the U.S., Council of Economic Advisors).

Figures 1–3 illustrate the time-series behavior of selected model variables. Figure 1 shows the decline in real feeder steer prices from about \$97 to \$57 per cwt from 1972 to 1999. Similarly, the real interest rate displays significant variation, showing a downward trend. Figure 2 shows a decline in U.S. calf crop numbers (attributed to decreased breeding cow inventories) and an upward trend in feeder cattle imports through 1995. Feeder imports precipitously declined thereafter. Stabilization of the Mexican cattle industry, genetic improvements and disease control, weather factors, peso devaluation, and excess capacity in U.S. cattle finishing accounted for much of the import increase (USDA 2001). Drought conditions which reduced Mexican cattle inventories severely reduced feeder cattle exports to the U.S. in 1996. Imports have gradually recovered since then. Figure 3 demonstrates the trends in U.S. cow-calf and feedlot technology. From 1972 to 1999, the former increased from 494 pounds to 631 pounds, or about 28%, and the latter increased from 55.4 thousand head per large feedlot to 98.9 thousand head, or about 79%.

Empirical Results

The 2SLS regression results for the lag structure of equation (5), estimated in double logs, are:

$$\begin{aligned}
 (6) \quad \ln(P_f) = & 6.078 - 0.280\ln(P_c) + 1.494\ln(P_s) - 1.554\ln(Q_f) - 0.039\ln(I(-1)) \\
 & (1.811)^* (-4.212)^{**} (16.956)^{**} (-3.501)^{**} (-1.509) \\
 & + 0.251\ln(P_h(-1)) - 0.161\ln(R) - 0.561\ln(T_c(-1)) + 0.211\ln(T_f) \\
 & (2.386)^{**} (-2.712)^{**} (-2.256)^{**} (2.729)^{**} \\
 & + 0.242D73 - 0.426\mu(-1) \\
 & (1.845)^* (-1.800)^* \\
 & \text{Adjusted } R^2 = 0.934, \quad \text{Durbin-Watson} = 1.924, \\
 & \text{Standard Error} = 0.047, \quad F\text{-Statistic} = 35.802.
 \end{aligned}$$

Single and double asterisks (* and **) denote significance at $\alpha = .10$ and $\alpha = .05$, respectively, with 18 degrees of freedom. Asymptotic t -ratios are given in parentheses. Note in the model that a binary variable ($D73$) has been added because a significant upward spike occurred in 1973 in feeder cattle price. Nominal feeder price in 1973 was \$52.15/cwt, which was \$11.49/cwt higher than in 1972 and \$15.92/cwt higher than in 1974. This anomaly was a result of President Nixon's 1971 wage and price controls (including food) and the 1972 continuation of retail beef price controls. After the beef price controls were lifted, cattle and beef prices rose to abnormally high levels in 1973 (Knutson, Penn, and Boehm).

The overall fit of the equation is relatively strong, with an adjusted R^2 of 0.93, standard error of regression of 4.7%, and F -value of 35.8. Figure 4 illustrates actual and predicted values of real feeder prices (antilog). The sample predictions perform relatively well. The root mean squared error (2.46) is 3.6% of the real mean feeder price, and Theil's U -coefficient (0.02) is near zero.

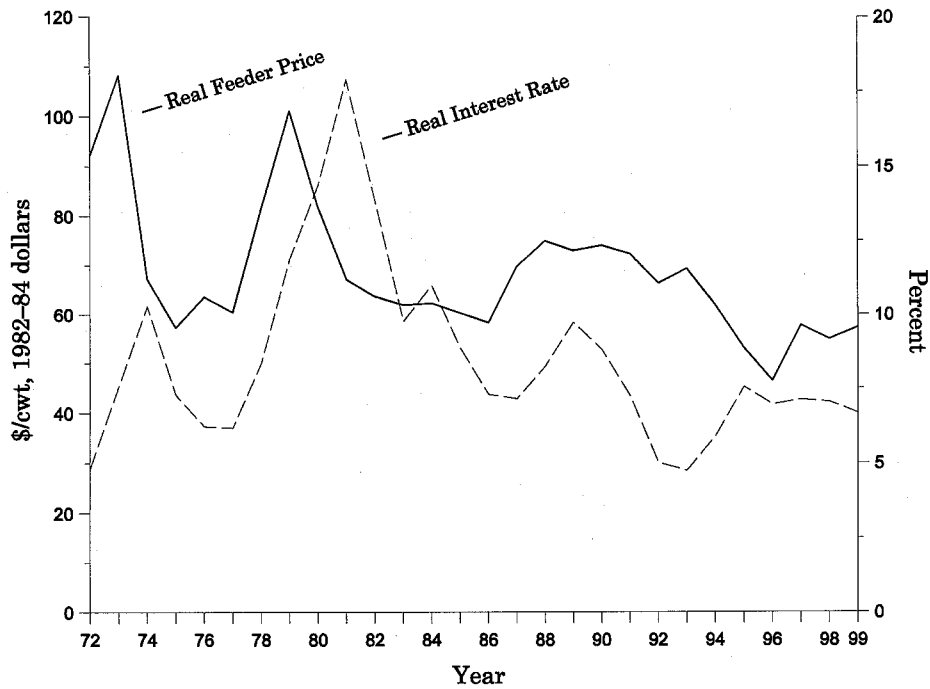


Figure 1. Real feeder steer price and real prime interest rate

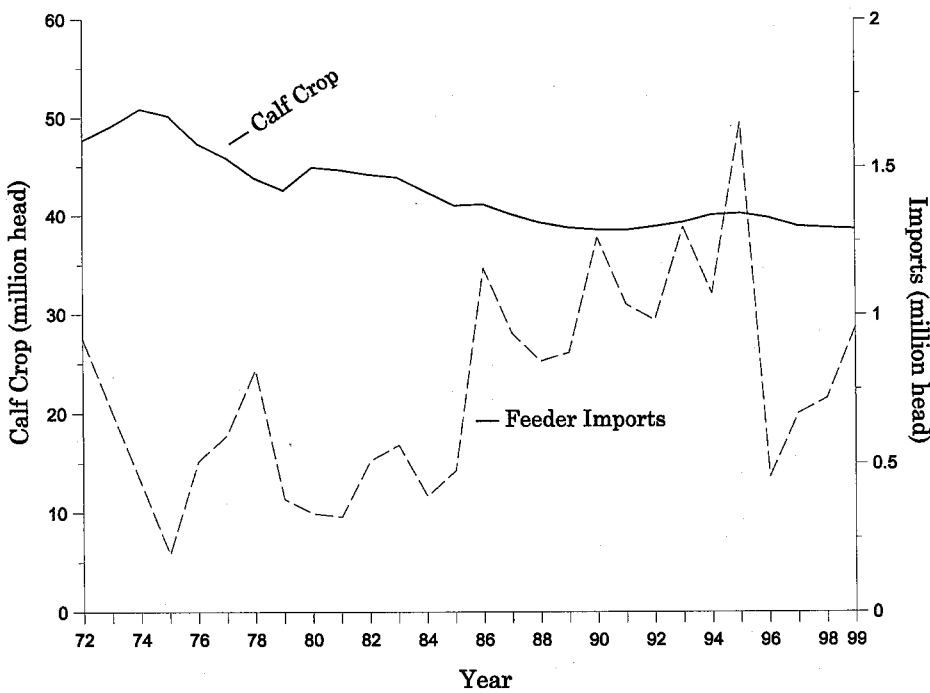


Figure 2. U.S. calf crop and Mexican feeder cattle imports

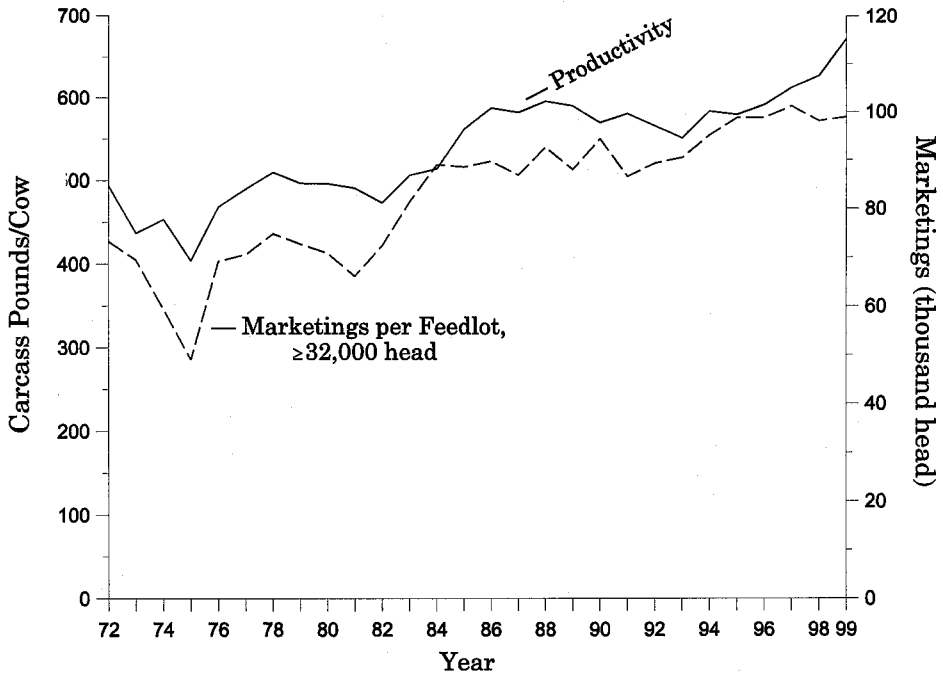


Figure 3. U.S. beef cow productivity and marketings per large feedlot

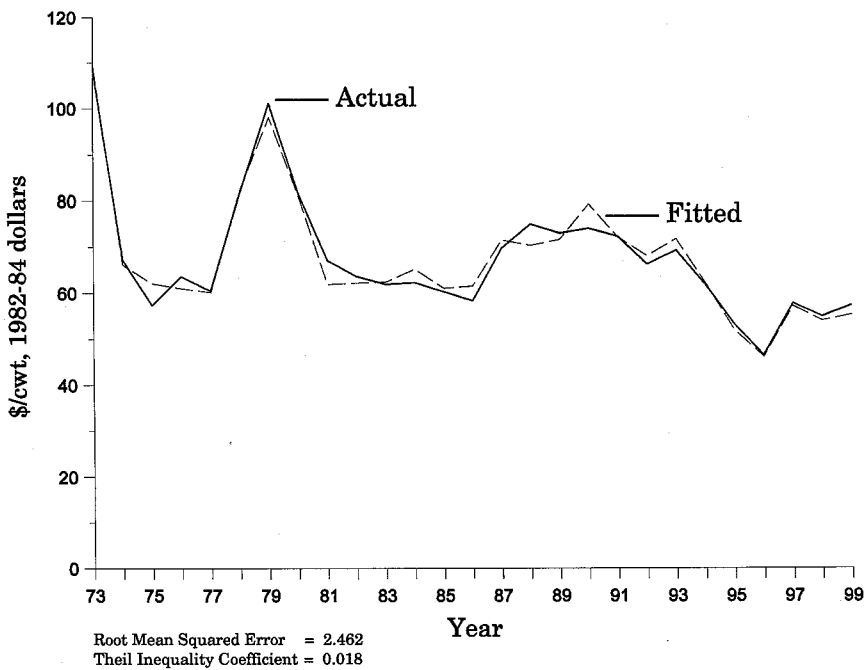


Figure 4. Observed and predicted values of real feeder steer price

Table 1. Estimated Changes in Real Feeder Steer Price Due to Volatility in Market Variables, 1980–1999

Regressor	Flexibility ^a	Sx/\bar{X} ^b	Percentage ^c	Price Impact ^d (\$/cwt)
Price Corn (P_c)	-0.280	0.394	0.110	7.54
Price Slaughter (P_s)	1.494	0.190	0.283	19.40
Feeder Supplies (Q_f)	-1.554	0.084	0.131	8.98
Interest Rate (I)	-0.039	0.359	0.014	0.96
Price Hay (P_h)	0.251	0.152	0.038	2.60
Market Risk (R)	-0.161	0.222	0.036	2.47
Feedlot Technology (T_f)	0.211	0.164	0.035	2.40
Cow-Calf Technology (T_c)	-0.561	0.114	0.064	4.39
Feeder Imports ^e	-0.028	0.465	0.013	0.89

^a Flexibility is the price flexibility coefficient for each variable estimated in equation (6).

^b Sx/\bar{X} is one standard deviation of the x regressor divided by its sample mean.

^c Percentage change in real feeder price due to regressor volatility ("Flexibility" multiplied by Sx/\bar{X} , signs ignored).

^d Price impact denotes dollar/cwt change in real feeder steer price ("Percentage" multiplied by sample mean of \$68.55/cwt).

^e Feeder imports denote Mexican feeder cattle imports. The price flexibility of -0.028 is the feeder supply price flexibility of -1.554 multiplied by Mexican feeder imports as a percent of feeder supplies (Q_f), which is 0.018. The Sx/\bar{X} calculation (0.465) is the standard deviation of feeder imports divided by the mean of feeder imports.

Table 1 reports the relative impacts on feeder price from exogenous market shocks. An example of calculating feeder price response to a standardized change in an exogenous variable is given by:

$$(7) \quad P_f^* = \frac{\partial \ln(P_f)}{\partial \ln(X)} \cdot \frac{Sx}{\bar{X}} \cdot \bar{P}_f,$$

where the left-hand-side term, P_f^* , is the \$/cwt change in real feeder steer price caused by volatility in exogenous variable X . The right-hand-side terms in equation (7) are defined as follows: $\partial \ln(P_f)/\partial \ln(X)$ is the estimated price flexibility coefficient with respect to X ; Sx/\bar{X} is one standard deviation of variable X divided by its sample mean (denoted the standard deviation ratio); and \bar{P}_f is the sample mean of real feeder steer price. The standard deviation ratio represents volatility in the X variable. An example of trend effects is represented by:

$$(8) \quad P_f^t = \frac{\partial \ln(P_f)}{\partial \ln(X)} \cdot \frac{X_t - X_0}{X_0} \cdot \Delta P_f,$$

where P_f^t is the \$/cwt change in feeder price due to a trend in the X variable. The first right-hand-side term is the estimated price flexibility coefficient with respect to X , the second term is the percentage change in X from the initial period (0) to the ending period (t), and the last term is the \$/cwt change in real feeder price over the defined period.

Slaughter and Corn Price Effects

Fed cattle prices demonstrate a highly significant and large impact on feeder prices—an expected effect because slaughter price is a critical component of feedlot profitability.

The price transmission elasticity indicates a 1% increase (decrease) in slaughter price produces a corresponding increase (decrease) in feeder steer price of 1.49%. This estimate is consistent with findings of Shonkwiler and Hinckley (1.34%), Marsh 1988 (1.62%), and Buccola (1.36%), whose respective study sample periods were 1972–1981 (bimonthly), 1967–1985 (quarterly), and 1968–1977 (fall quarter). As shown in table 1, the standard deviation ratio of real slaughter price is 19%. Therefore, the volatility in real slaughter price accounted for \$19.40/cwt or 28.3% of the changes in real feeder price about its mean of \$68.55/cwt.

Corn price, a critical cost component in producing fed cattle, is also statistically significant. Changes in corn prices affect the cost of gain and cattle finishing margins, which, in turn, influence prices bid on feeder placements. However, corn price affects feeder price considerably less than slaughter price; a 1% increase (decrease) in corn price results in a decrease (increase) in feeder price of about 0.28%. This coefficient is slightly less than those of other feeder studies; e.g., Shonkwiler and Hinckley reported a corn price elasticity of -0.48 , Marsh (1985) noted an elasticity of -0.30 , and Buccola -0.32 . The standard deviation ratio of real corn price is 39.4%. This volatility accounted for an 11% change in real feeder price about its sample mean, or \$7.54/cwt.

Interest Cost, Profit Risk, and Hay Price

Empirical results show profitability risk is significant (at $\alpha = .05$) and negatively shifts the derived feeder price. Although hedging opportunities to reduce fed cattle and corn price risk existed throughout the sample period, in all likelihood extensive hedging (particularly cattle) has occurred more in recent years. A 1% increase in profitability risk reduces real feeder price by about 0.16% (table 1). In terms of market volatility, the variable displays a nonzero effect on feeder price. For example, the standard deviation ratio of profitability risk is relatively large at 22.2%, and the resulting change in real feeder price about its mean was \$2.47/cwt. While interest rate demonstrated a negative impact on feeder price, it is statistically weak (significant at the $\alpha = .15$ level). Though not as meaningful, its impact on feeder price was about \$0.96/cwt.

The coefficient of lagged hay price is positive and statistically significant at the $\alpha = .05$ level. Rucker, Burt, and LaFrance, in an econometric analysis of U.S. cattle inventories, found the effect of lagged hay *production* was positive and statistically significant. However, the estimated marginal impact in their study was quite small. The marginal impact of hay price in the current study is nearly equal to that of corn. Volatility in hay prices over the sample period was 15.2%, accounting for a change in feeder price of approximately \$2.60/cwt.

Feeder Quantities and Imports

The statistical effect of feeder cattle supplies on feeder price is highly significant. The price flexibility coefficient is also relatively large, revealing a 1% increase in feeder supplies reduces feeder price by 1.55% (table 1). Brester and Marsh (1983), and Shonkwiler and Hinckley estimated feeder cattle price flexibilities of -1.61 and -1.10 , respectively. The model coefficient suggests small changes in the domestic supply of feeder cattle can have a profound impact on prices received by ranchers. For example, from 1990 to 1995, the U.S. calf crop increased from 38.8 to 40.7 million head, or by 4.9%. Based on a real

mean feeder price of \$66.19/cwt for this period, the increase in the U.S. calf crop meant a \$4.95/cwt drop in the real feeder price. The volatility or standard deviation ratio of feeder supplies was 8.4%, which resulted in a relatively large change in feeder price of \$8.98/cwt.

Concerns about the effects of Canadian slaughter cattle imports on U.S. fed cattle prices are paralleled by concerns about the impact of Mexican feeder cattle imports on U.S. feeder cattle prices. Although U.S. feeder cattle imports have substantially increased, they remain a small percentage of total feeder cattle supplies. From 1975 to 1995, feeder cattle imports increased from 196.1 thousand head to 1.65 million head, or from 0.38% to 3.96% of U.S. feeder cattle supplies. Declines in feeder imports have occurred since 1995. For the sample period, U.S. feeder imports as a percentage of total feeder supplies averaged 1.8%, but were higher at 2% for the 1980–1999 period.

One approach to evaluating the effect of feeder cattle imports on U.S. feeder price would be to hypothetically eliminate the *average* level of imports. To illustrate, consider applying the model results to the 2% import share during the 1980–1999 period. Assuming domestic feeder supplies are unchanged, a zero Mexican import share (hence, less total feeder supplies) indicates real feeder price would have averaged \$2/cwt higher during this period (based on \$64.37/cwt real mean price).

Another approach would be to consider a *change* in market share. For example, from 1980 to 1999, the feeder import share increased by 1.6% and real feeder price declined by \$24.48/cwt. This approach implies the increased import share contributed to about \$0.60/cwt, or 2.5% of the real feeder price decline. Volatility in feeder cattle imports was relatively large (46.5%), which resulted in the feeder import share causing real feeder price to change by approximately \$0.89/cwt about its mean. Work by Cockerham, based on 1973–1992 monthly data, showed that increased imports of 400 to 500 pound Mexican feeder calves decreased U.S. feeder calf price by an average of \$0.38/cwt in 1992 dollars, with the decrease actually ranging as high as \$1.98/cwt based on maximum monthly imports. Although these results involve different time periods and weight ranges compared to the current annual model, they corroborate findings of nonzero price impacts of Mexican feeder imports.

Technology

The coefficient of beef cow productivity is negative and statistically significant at the $\alpha = .05$ level. This technology is primarily rooted in breeding genetics and management of health and nutrition at the farm level. However, since the productivity measure involves dressed weights, it also reflects weight gains in feedlots. Consequently, it is noted that output per beef cow can reflect management beyond the farm level. Technology improvements affecting supplies are expected to decrease market price. Model results report a relatively large response from beef cow productivity. A 1% increase reduces feeder steer price by 0.56% (table 1). In terms of its market volatility, productivity changes perturbed real feeder price by \$4.39/cwt about its mean. From a trend standpoint, beef cow productivity increased by a substantial 35.5% from 1980 to 1999. Consequently, its effect on feeder price was not trivial. Of the \$24.48/cwt decrease in real feeder price for this period, \$4.86/cwt is attributed to cow-calf technology.

The coefficient of finishing technology represented by feedlot size is positive and statistically significant at the $\alpha = .05$ level. Based on the positive coefficient, a 1% increase in

feedlot size increases feeder price by 0.21%. Thus, on a national basis, cost efficiencies of large feedlots appear to benefit cow-calf producers. Another aspect of efficiency, not necessarily captured by feedlot size, may be improved (hotter) feed rations which have increased feedlot turnover.

Conclusions

This econometric analysis of equilibrium feeder cattle prices shows that economic factors beyond slaughter and feed grain prices—interest rate, profit risk, hay cost, and ranch and feedlot technologies—have important impacts on feeder cattle price. For example, standard deviation ratios indicate these other variables collectively affect real feeder price by \$12.82/cwt, which is about 66% of the major effect of slaughter price. The collective effect of cow-calf and feedlot technologies was about 90% of the volatility effect of corn prices. Based on the model results, reduction of feeder cattle imports would increase feeder price. For example, if the Mexican feeder import share had been reduced to its minimum value (0.70%) during the 1980–1999 period, U.S. feeder price would have increased by about \$0.70/cwt. This estimate does not account for any domestic supply response. Growth in large feedlots, representing cost-saving technological change in cattle finishing, has positively affected feeder prices. The study findings confirm this growth prevented feeder prices from declining by about \$2.04/cwt from 1980–1999.

Technological adoption in the cow-calf sector, primarily through breeding genetics, has substantially increased. Model results disclose that increases in carcass pounds per beef cow substantially contributed to declines in real feeder prices. These productivity increases accounted for nearly 20% of the decline in real feeder price from 1980–1999. Consequently, increases in domestic and export demand for beef products (which affect slaughter price) are necessary to offset decreases in real feeder price caused by technological advances that increase beef pounds.

Based on model results, fluctuations in the prime interest rate which influence the cost of capital could affect feeder prices. Although the effect of interest rate on 700–800 pound cattle placed in feedlots was marginal, the impact could be greater on prices of lighter weight feeders that begin with stocker grazing and end with grain finishing (i.e., larger carrying costs). The significance of feedlot profit risk suggests risk management policies, such as forward pricing mechanisms which reduce the price risk associated with feed grains and fed cattle, could improve feeder cattle demand and result in price gains to cow-calf operators.

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