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

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Objective Analysis
for Informed
Decision Making

Research Discussion Paper No. 47

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Abstract

Analysis of U.S. feeder steer prices normally includes factors in the fed cattle and feed grain markets, but an expanded econometric model includes finance cost and profit risk, hay cost, and cow-calf and feedlot technology. In addition, effects of total feeder supplies and Mexican and Canadian feeder cattle import shares are investigated. Model results indicate statistical significance of all variables. Feeder import share is relatively small, however, because of a large price flexibility, a zero share would have entailed a higher feeder price of $2.52/cwt from 1980–1998. Increased cow-calf technology significantly reduced feeder price, i.e., by $5.72/cwt from 1980 to 1998. Increased feedlot technology through cost savings increased feeder price. Macro-interest rate policies and feedlot risk management will continue to affect feeder prices.

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

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Introduction

Beef producers determining breeding herd size base their decisions on many factors, 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, beef operators purchasing feeder cattle for backgrounding or finishing programs base their decisions, besides feed costs, on input prices of feeders (Anderson and Trapp; Shonkwiler and Hinckley). With feeder cattle prices playing crucial roles in production and marketing decisions, factors that determine their expected levels are critical information in commodity analysis.

The purpose of this article is to develop the derived demand and primary supply structure of the U.S. feeder cattle sector and econometrically estimate equilibrium U.S. feeder cattle price. Emphasis is on quantifying domestic information excluded from previous research, evaluating the effects of Mexican and Canadian feeder cattle import shares, and assessing the effects of cow-calf technology and feedlot technology. Structural modeling in the beef sector has primarily focused on the retail, slaughter, and marketing margin levels (Arzac and Wilkenson; Azzam and Anderson; Brester and 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). However, with the exception of Anderson and Trapp, previous work is dated. In addition, demand and supply behavior has primarily focused on factors in the slaughter cattle and feed grain markets, ignoring other market shocks.

Normally, prices in the feeder cattle market respond to changes in slaughter cattle prices and feed costs (Anderson and Trapp; Buccola; Shonkwiler and Hinckley). However, it is hypothesized that firm behavior in producing and adding value to feeder cattle behooves analyzing other factors that affect feeder price. These factors, excluded from previous econometric work, include finance costs, profit risk, cow-calf and feedlot technology, and U.S. imports of feeder cattle. The importance of these factors has evolved from changing price discovery and marketing programs, breeding and nutrition programs, excess capacity in cattle finishing, and production and marketing efficiencies. Results of the empirical study are important information to cow-calf producers, backgrounders, and cattle finishers whose relevant marketing (purchase or sale) decisions depend on future expectations of feeder calf and yearling prices.

Background Information

Though 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. Due to borrowing requirements in feeder cattle production, retained ownership, and in cattle finishing (Duncan et al.), the opportunity cost of capital (interest rate) would not be trivial in affecting feeder prices. Ignoring interest cost in models of feeder demand (price) could result in specification error due to its cost importance and market volatility. For example, in 1998 interest cost in Great Plains custom finishing averaged about 17 percent of total cost of gain (USDA), and from 1970–1998 the standard deviation of the prime interest rate was about 33 percent of its mean value (Economic Report of the President). Profitability risk in cattle feeding has also largely been ignored in models of feeder prices. However, risk factors in beef margin analysis 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, however, basis volatility is significant (LMIC). Consequently, profitability risk in cattle finishing persists. From 1970 to 1998, the standard deviation of the ratio of steer price to corn price (proxy for feedlot profitability) was about 24 percent of its mean value.

Technological changes in the beef sector, more 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 involved breeding genetics and health and nutrition management 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). 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 (and Canadian) cattle inventories, U.S. cattle prices, and excess capacity in U.S.

[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 (used in this study) uses dressed weights of steer and heifer offspring, which reflect breeding genetics and rancher management programs that affect weaning weights and subsequent weight gains. An ideal measure of finishing technology would be feeding efficiency such as pounds of grain to yield 1 pound of weight gain. However, 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.

cattle finishing (Peel). USDA data indicate that feeder cattle imports from Mexico and Canada have substantially increased, i.e., from 211.4 thousand head in 1975 to a peak of 1.7 million head in 1995. Import market share (Mexican and Canadian feeder cattle imports as a percentage of total U.S. feeder supplies) permits evaluating the foreign influence on U.S. feeder price. This would be an important sequel to recent work estimating the effects of Canadian slaughter cattle imports on U.S. fed cattle prices (Brester and Marsh 1999).

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 demands and supplies are commonly used in agricultural commodity models, particularly if production quantities are considered predetermined and market prices are endogenous (Dunn and Heien; Eales; Huang). 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) $$P_f^d = f_1(Q_f^d, P_s, P_m, I, R, T_f)$$ (inverse demand)

(2) $$P_f^s = f_2(Q_f^s, I, P_h, T_p)$$ (inverse supply)

(3) $$Q_f^d = Q_f^s = Q_f$$ (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 price of medium No. 1, 600–650 lbs, feeder steers, Oklahoma City (dollars/cwt); Q_f^d, Q_f^s are respective total quantities demanded and supplied of U.S. feeder cattle–*total* consisting of lagged (one year) U.S. calf crop and imports of Mexican and Canadian feeder cattle (mil head); P_s is price of choice 2–4, 1100–1300 lbs, U.S. slaughter steers, Nebraska direct (dollars/cwt); P_m 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 marketings from large feedlots, which is total fed cattle marketed from feedlots ≥32,000 head divided by number of feedlots ≥ 32,000 head, 13 states; and T_p is technology at the feeder production level, proxied by U.S. beef cow productivity. Productivity is defined as: [(steer slaughter x average dressed weight of steers + heifer slaughter x average dressed weight of heifers) - (Canadian cattle imports x average dressed weight of steers + Mexican cattle imports x average dressed weight of heifers)] ÷ (U.S. beef cow inventories x 0.95). Since USDA estimates of commercial steer and heifer slaughter include cattle imports, estimated carcass weight imports 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 the U.S. feedlots). The multiplication factor of 0.95 is used since it is assumed that 95 percent of January 1 beef cow inventories will calve.

Equation (1) represents the demand (input) price for feeder cattle by domestic cattle finishers. Demand price depends upon feeder quantities demanded (Q_f^d), output price (P_s), input

costs (P_m, I), profitability risk (R), and feedlot technology (T_f). Feeder quantities demanded are aggregated, i.e., demand for domestic feeders and imported feeders. It is assumed that changes in import quantities of Mexican and Canadian feeders would impact U.S. feeder price no differently than changes in quantities of U.S. born feeders. Market shares of feeder imports, i.e., feeder cattle imports as a percentage of total U.S. feeder supplies, are used to evaluate the foreign impact on price.[2] The expected impact of Q_f^d on feeder price is negative. Output price of slaughter steers (P_s) is a derived demand shifter, and is expected to positively impact feeder price (i.e., higher slaughter price increases feedlot profitability, hence, the demand for feeders). Similarly, the input costs of corn (feed price) and capital (interest rate) are derived demand shifters; their expected impacts on feeder price are negative (i.e., higher corn price or interest rate decreases feedlot profitability, hence, 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 Kohlhagen). Assuming that cattle finishers are risk averse, it is expected that an increase in profitability risk would shift derived feeder demand to the left, hence, reducing feeder price. Finishing technology (T_f) represented by growth in marketings per large feedlot (≥32,000 head) proxies unit cost changes that would shift derived demand for feeders. However, this variable could also reflect potential market power in

[2] 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).

The market share analysis is in retrospect. That is, *causes* of changes in U.S. feeder imports are not quantified, only that exogenous changes have occurred and that import shares imply a feeder quantity impact on price.

purchasing feeders (a concentration ratio is not calculated for the feedlot industry). Under competitive conditions, an increase in technology would increase feeder price as cost savings are passed on to feeder producers. But if market power dominates with large size, the empirical results could show a negative effect on feeder price.

Equation (2), or inverse supply, represents the U.S. supply price of feeder cattle by cow-calf and yearling producers. Supply price (P_f^s) depends upon total quantity of feeder cattle supplied (Q_f^s), input costs of interest (I) and hay (P_h), and ranch-level technology (T_p). Hay prices in many areas of the United States are relevant to costs of maintaining beef cow herds and retaining ownership of calves (*Managing Today*). Hay prices may also reflect weather and pasture and range conditions.[3] Interest rate or the cost of borrowed capital could affect cow herd expansion (contraction), hence, quantities of feeders produced. From a production standpoint, increases in input prices of interest and hay would theoretically shift the supply curve of feeder cattle to the left. Technology at the cow-calf level, which reduces unit costs of producing weanling calves, would theoretically increase weaning weights and shift the supply curve of feeders to the right, decreasing feeder price.

Empirical Model and Estimation

Given structural demand and supply equations (1) and (2) and market clearing price and quantity equations (3) and (4), the model can be solved for equilibrium feeder price. Because of production lags caused by biological growth, feeder supplies are assumed predetermined. Then

[3] For example, increased hay costs would be commensurate with poor pasture and forage conditions caused by inadequate rainfall, which, with lag adjustments, could affect feeder supplies.

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) $$P_f = g(Q_f, P_s, P_m P_h, I, R, T_f, T_p, \mu_t).$$

Equation (5) describes the demand-supply arguments expected to determine the behavior of equilibrium feeder cattle price. An error term (μ_t) with assumed classical properties is added. The equation appears as a reduced form, with the expected marginal impact of each variable consistent with its described impact in the structure. Interest rate appears in both the demand and supply equations, however, and its net effect will be determined by the empirical results.

All equation variables were tested for nonstationarity by the Augment Dickey-Fuller unit root test (ADF). The null hypothesis of unit roots could not be rejected for any variable, with all variables integrated of order one (I(1)). The Johansen cointegration test indicated the equations were co-integrated as well as did the ADF test of the equation residuals. However, DeJong et al. argue that in small samples the preceding tests have low power against the trend stationary alternative. As a result, the current model is estimated in data-level form. Furthermore, Johnston and DiNardo (p. 317) indicate that if a model contains simultaneous relationships, nonstationarity and cointegration are not of concern and traditional simultaneous estimation methods are appropriate.

Though feeder cattle supplies are assumed predetermined, joint dependency was tested in equation (5) because of including slaughter steer price as a regressor, i.e., shifts in dependent feeder steer price (an input cost in cattle finishing) could be transmitted to the cattle finisher's

output price. The Hausman specification test for slaughter price was confirming, i.e., the null hypothesis of no simultaneous equation bias was rejected at the $\alpha = .05$ significance level.[4]

Other tests were conducted on the model. In summary, they include the following: (1) the Jarque-Bera test failed to reject the null hypothesis of normally distributed residuals; (2) Whites test failed to reject the null hypothesis of homoskedastic errors; (3) the Durbin-Watson test indicated a negative AR(1) error structure; and (4) 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 (TSLS) with an AR error correction was the estimator employed.[5] 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 on 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).

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[4] For confirmation of its exogeneity, the Hausman specification test was applied to total 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.

[5] The instruments used for TSLS 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.

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 1998 are used to estimate the model. All price variables and interest rate are expressed in real terms, deflated by the Producer Price Index (PPI, 1982 = 100). The feeder, slaughter, and corn price variables, U.S. calf crop, Mexican feeder imports, Canadian live cattle imports, and variables used in constructing beef cow productivity were obtained from the USDA's Red Meat Yearbook (on disc), the USDA's Livestock, Dairy and Situation Outlook reports (LDP), and the Livestock Marketing Information Center (LMIC). Data on feedlot marketings and number of feedlots (13 states, $\geq$ 32 thousand head) were also obtained from the LMIC. Hay price was obtained from the USDA's Agricultural Statistics. The PPI and prime interest rate were obtained from the Economic Report of the President. Disaggregated data on live cattle imports from Canada, i.e., slaughter cattle and feeder cattle, were available only from the fourth quarter of 1993 through the fourth quarter of 1998. Consequently, Canadian feeder cattle imports from 1970 through 1993 were estimated. Estimates were made by multiplying Canadian live cattle imports by 8 percent, which was the feeder import percentage of Canadian live cattle imports in the fourth quarter of 1993. It was rationalized this procedure was

better than omitting Canadian feeder cattle imports altogether.[6] From 1994 through 1998, feeder cattle imports from Canada exceeded 5 percent of total U.S. feeder cattle imports, but from 1996 through 1998 this figure was about 12 percent.

Figures 1 through 3 illustrate the time-series behavior of selected model variables. Figure 1 shows the decline in real feeder steer price, i.e., from about $97.00/cwt in 1972 to about $54/cwt in 1998, and the behavior of interest rate. Real interest rate displays significant variation, as well as showing a downward trend. Figure 2 shows the decline in U.S. calf crop (attributed to decreased breeding cow inventories) and an upward trend in feeder cattle imports through 1995. Feeder imports precipitously declined thereafter. Long-term increases in Mexican and Canadian breeding herds, a strong U.S. dollar, and excess capacity in U.S. cattle finishing accounted for much of the import increase. After 1995 (the Mexican peso crisis) the peso strengthened, drought conditions reduced Mexican cattle inventories, and increased capacity in Canadian feedlots reduced feeder cattle exports to the United States. Figure 3 demonstrates the trends in U.S. cow-calf and feedlot technology. From 1972–1998 the former increased from 494 pounds to 627 pounds, or about 27 percent, and the later from 55.4 thousand head per large feedlot to 98.1 thousand head, or about 77 percent.

[6] In other empirical estimation (not shown), exclusion of estimated Canadian feeder imports from the total feeder supply variable, Q_f, changed the overall statistical results very little. The price flexibility coefficient changed from 1.78 (with Canadian feeders) to 1.74 (without Canadian feeders). This result confirms that any measurement error associated with inclusion of estimated Canadian feeders was quite minimal.

Empirical Results

The TSLS regression results for equation (5) (lag structure) are given as (double logs):

(6)
$$\ln P_f = 7.408 - 0.278 \ln P_m + 1.576 \ln P_s - 1.782 \ln Q_f$$
$$(2.045) \quad (-3.697) \quad (16.070) \quad (-3.734)$$

$$-0.072 \ln I(-1) + 0.221 \ln P_h(-1) - 0.149 \ln R$$
$$(-2.503) \quad (1.888) \quad (-2.360)$$

$$-0.700 \ln T_p(-1) + 0.300 \ln T_f + 0.203\, D73 - 0.497\, \mu(-1)$$
$$(-2.492) \quad (2.014) \quad (2.250) \quad (-1.991)$$

Adjusted R-squared =	0.925	Durbin Watson =	1.959
Standard Error =	0.054	F-Statistic =	31.083

Critical t values at $\alpha = .05$ and $\alpha = .10$ are 2.101 and 1.734, respectively (18 df).

The asymptotic t ratios are given in parentheses. Note in the model that a binary variable, D73, has been added. The data reveal in 1973 that a significant upward spike occurred in feeder cattle price, so detected by a large positive residual. 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 controls were lifted, abnormally high cattle and beef prices resulted in 1973 (Knutson, Penn, and Boehm).

The overall regression fit of the equation is relatively strong, with an adjusted R-squared of 0.93, standard error of regression (Standard Error) of 5.4 percent, and the F value of 31.1. Figure 4 gives the graph of the actual and predicted values of real feeder price (antilogs). The sample predictions perform relatively well, i.e., the Root Mean Squared Error (3.16) is 4.4 percent of real mean feeder price and Theil's U coefficient (0.02) is near zero.

In analyzing equation (6), its estimated coefficients as well as marginal impacts resulting from standardized shifts (or volatility) in the exogenous variables are discussed. In some cases

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

$$P_f^* = \frac{\partial \ln P_f}{\partial \ln X} \bullet \frac{Sx}{\bar{X}} \bullet \bar{P}_f, \tag{7}$$

where the left-side term, P_f^*, is the \$/cwt change in real feeder steer price caused by volatility in exogenous variable X. The right-side terms in equation (7) are: $\frac{\partial \ln P_f}{\partial \ln X}$ is the estimated price flexibility coefficient with respect to X; $\frac{Sx}{\bar{X}}$ is one standard deviation of variable X divided by its sample mean (called 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 given as:

$$P_f^t = \frac{\partial \ln P_f}{\partial \ln X} \bullet \frac{X_t - X_o}{X_o} \bullet \Delta P_f, \tag{8}$$

where the left-side term, P_f^t, is the \$/cwt change in feeder price due to a trend in the X variable. The right-side terms are: the first 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 price demonstrates a highly significant and large impact on feeder cattle price, which is expected since slaughter price is a critical component of feedlot profitability. The price

transmission elasticity indicates a 1 percent increase (decrease) in slaughter price increases (decreases) feeder steer price by 1.58 percent. The coefficient is consistent with those estimated by Shonkwiler and Hinckley (1.34 percent), Marsh 1988 (1.62 percent), and Buccola (1.36 percent). As shown in table 1, the standard deviation ratio of real slaughter price is 18.5 percent. Therefore, volatility in real slaughter price accounted for changes in real feeder price about its mean of 29.2 percent, or $20.89/cwt. (Real mean feeder price is $71.55/cwt).

Corn price, a critical cost component in producing cattle finishing weight, is also statistically significant. However, it affects feeder price considerably less than that of slaughter price. Results indicate a 1 percent increase (decrease) in corn price decreases (increases) feeder price by about 0.28 percent. This coefficient is slightly less than those of other feeder studies. For example, Shonkwiler and Hinckley indicate a corn price elasticity of -0.48, Marsh (1985) indicates a corn price elasticity of -0.30, and Buccola shows a corn price elasticity of -0.32. The standard deviation ratio of real corn price is 38.3 percent. This volatility accounted for a 10.6 percent change in real feeder price about its sample mean, or $7.58/cwt.

Interest Cost, Profit Risk, and Hay Price

The empirical results indicate interest rate and profitability risk are significant and negatively shift derived feeder price. Though hedging opportunities to reduce fed cattle and corn price risk existed throughout the sample period, in all likelihood extensive hedging (particularly cattle) has occurred in the more recent years. Basis volatility, a contributor to risk, has always existed. The coefficients are statistically significant at the $\alpha = .05$ level, however, the marginal impacts are relatively small. For example, 1 percent increases in real interest rate and profitability risk reduce real feeder price by about 0.07 and 0.15 percent, respectively. In terms of

market volatility, both variables display nonzero effects on feeder prices. For example, the standard deviation ratios of interest rate and profitability risk are relatively large at 36.0 percent and 22.3 percent, respectively. The resulting changes in real feeder price about its mean were $1.86/cwt and $2.38/cwt, respectively.

The coefficient of lagged hay price is positive and statistically significant at the $\alpha = .10$ level. Rucker, Burt, and LaFrance in an econometric analysis of U.S. cattle inventories found that the effect of lagged hay *production* was positive and statistically significant. However, the marginal impact was quite small. In part, the small impact of national hay price in the current study reflects substantial regional hay price differences due to varying weather conditions and large transportation costs. Volatility in hay prices over the sample period was about 15 percent, and accounted for nearly a $2.30/cwt change in feeder price.

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, indicating a 1 percent increase in feeder supplies reduces feeder price by 1.78 percent. Brester and Marsh and Shonkwiler and Hinckley indicated feeder cattle price flexibilities of -1.61 and -1.10, respectively. The model coefficient infers that 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 domestic feeder supplies increased from 38.8 to 40.7 million head, or by 4.9 percent. Based upon a real mean feeder price of $61.02/cwt for this period, the increase in the U.S. calf crop meant a $5.00/cwt drop in real feeder price. In terms of the standard deviation ratio (8.3 percent), the volatility effects of feeder supplies are quite substantial, i.e., a $10.59/cwt change in feeder price about its sample mean.

Concerns about the effects of Canadian slaughter cattle imports on U.S. fed cattle prices are paralleled by concerns about the impact of feeder cattle imports (primarily from Mexico) on U.S. feeder cattle prices. Although U.S. feeder cattle imports have increased dramatically, they remain a small percentage of total feeder cattle supplies. For example, from 1975 to 1995 feeder cattle imports increased from 211.4 thousand head to 1.67 million head, or from 0.41 percent to 3.93 percent 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 only 1.8 percent, but increased to 2.1 percent for the 1980–1998 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. For example, consider applying the model results to the 2.1 percent import share during the 1980–1998 period. Assuming domestic feeder supplies unchanged, a zero Mexican and Canadian import share (hence, less total feeder supplies) indicates real feeder price would have averaged $2.52/cwt higher during this period (based upon $67.22/cwt real mean price). Another approach would be to consider a *change* in market share. For example, from 1980 to 1998 the feeder import share increased by 1.1 percent and real feeder price declined by $30.96/cwt. This implies that, had the share not increased (or less total feeder supplies), the decline in real feeder price would have been less by $0.61/cwt. In table 4 volatility in feeder cattle imports was relatively large (46.0 percent), which resulted in the feeder import share causing real feeder price to change by $1.07/cwt about its mean. Work by Cockerham, based on 1973–1992 monthly data, showed that increased imports of 400–500 pound Mexican feeder cattle resulted in decreasing U.S. feeder cattle price by an average of $0.38/cwt in (1992 dollars). However, the decrease ranged as high as $1.98/cwt.

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 health and nutrition management at the farm level. However, since the productivity measure involved 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 that affect supplies are expected to decrease market price. Model results indicate a relatively large response, i.e., a 1 percent increase in beef cow productivity reduces feeder steer price by 0.70 percent. In terms of market volatility, productivity changes resulted in $5.58/cwt changes in real feeder price about its mean. From a trend standpoint, beef cow productivity increased by 26.4 percent from 1980 to 1998. Consequently, its affect on feeder price was not trivial, i.e., of the $30.96/cwt decrease in real feeder price for this period, $5.72/cwt was attributed to the technology increase.

The coefficient of finishing technology is positive and statistically significant at the $\alpha = .10$ level. The positive coefficient indicates that a 1 percent increase in finishing technology increases feeder price by 0.30 percent. This result suggests that, on a national basis, monopsony power has not been predominant with increasing feedlot size. Rather, cost efficiencies presumed associated with large feedlots are competitively reflected in prices received by cow-calf producers. Other national feeder cattle studies did not measure the price effects of technology through feedlot size. However, Bailey, Brorsen, and Fawsen estimated *regional* effects of buyer concentration on feeder price at two major regional feeder cattle auctions (traditional and video). Monthly data from 1987–1989 was used. They found that increased buyer concentration was statistically significant and decreased prices of feeder steers and heifers by $0.05/cwt to

$0.44/cwt. (Different studies at the *slaughter* level indicate that the effects of *beef packer concentration* on slaughter cattle prices and beef margins are significant. However, the marginal impacts are small and mixed, depending upon findings of efficiency or market power (see Azzam and Anderson)).

Conclusions

Econometric analysis of equilibrium feeder cattle price indicates economic factors besides slaughter price and feed grains (interest rate, profit risk, hay cost, and ranch and feedlot technologies) importantly impact feeder cattle price. For example, standard deviation ratios indicate these other variables collectively impact real feeder price by $16.02/cwt, which is about 77 percent of the effect of slaughter price and about 151 percent of the feeder cattle supply effect. The effect of corn price volatility on feeder price was exceeded by the volatilities of cow-calf and feedlot technologies. Model results imply that elimination of the feeder cattle import share during 1980–1998 would have added $2.52/cwt to feeder price. However, this scenario is problematic since domestic supply response would likely have negated most of the gain. Growth in large feedlots, representing technological change in cattle finishing, positively affected feeder price likely through cost savings. Model results indicates this technological growth prevented feeder prices from further declines from 1980–1998, i.e., by about $3.57/cwt.

Technological adoption in the cow-calf sector, primarily through breeding genetics, has substantially increased. Model results indicate resulting gains in beef cow productivity substantially contribute to real feeder price declines. Productivity increases accounted for about 18.5 percent of the decline in real feeder price from 1980 to 1998. Increases in domestic and export demand for beef products (which affect slaughter price) will be key offsets to increasing

beef pounds caused by technological advances. For example, in the five year period from 1994 to 1998, beef cow productivity increased by 7.4 percent. Assuming no structural changes, if the five year period beyond the sample experiences the same productivity growth, feeder steer price would decline by about $4.40/cwt (using an average feeder price of $85/cwt). Consequently, slaughter steer price (which reflects primary demand) would need to autonomously increase by about 3.3 percent to offset this predicted decline.

Model results imply macro-interest rate policies will continue to affect producer prices. For example, from June 1999 to August 2000 the prime interest rate increased about 2 percentage points. Based on an average feeder price of $88/cwt, this results in a $0.13/cwt reduction in price. The significance of profit risk suggests that feedlot management policies which reduce price risk of feed and fed cattle (i.e., forward pricing mechanisms) can improve feeder cattle demand and result in price gains to cow-calf operators.

Figure 1. Real Feeder Steer Price and Real Prime Interest Rate

Figure 2. U.S. Calf Crop and Mexican and Canadian Feeder Cattle Imports

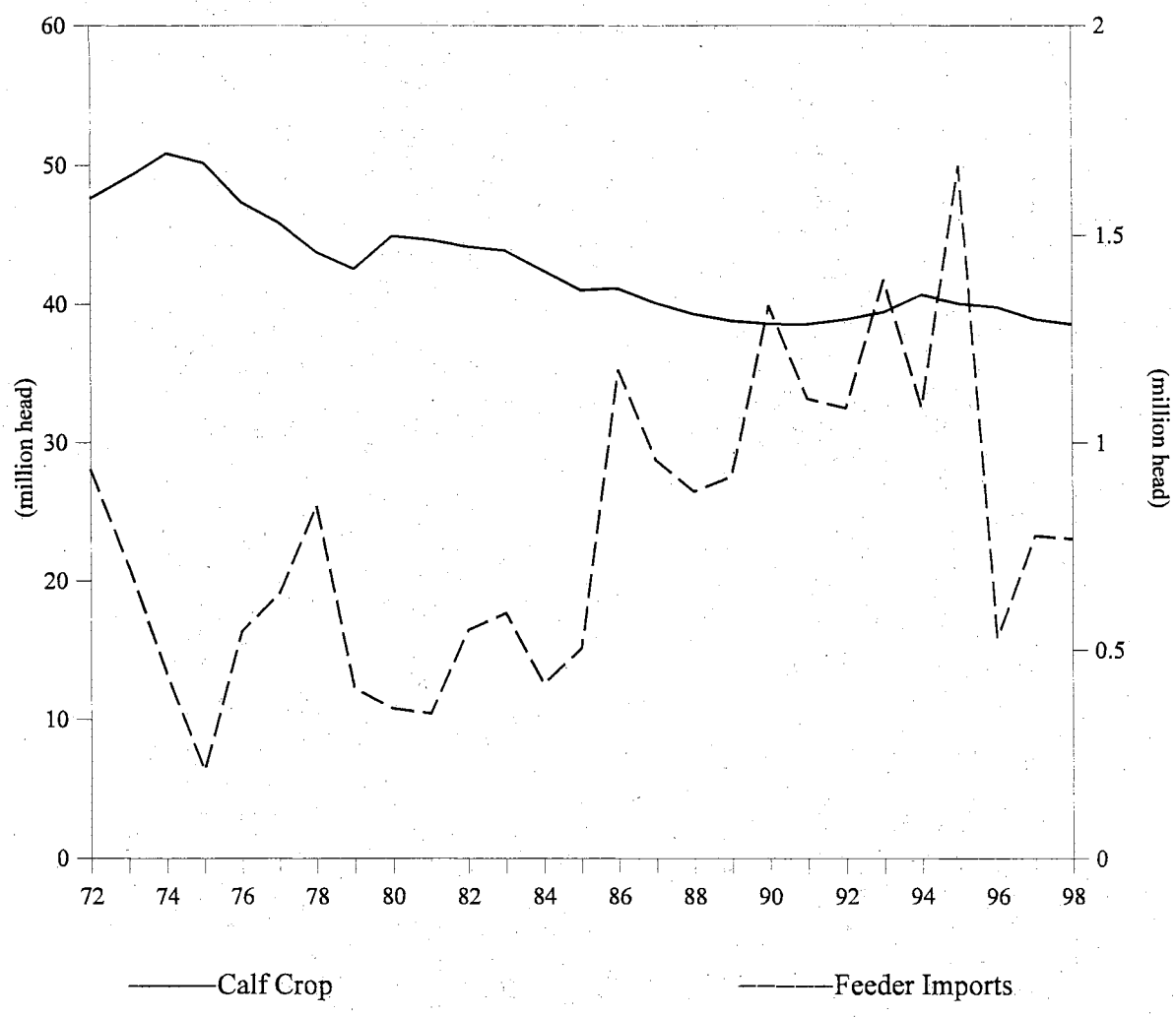


Figure 3. U.S. Beef Cow Productivity and Marketings Per Large Feedlot

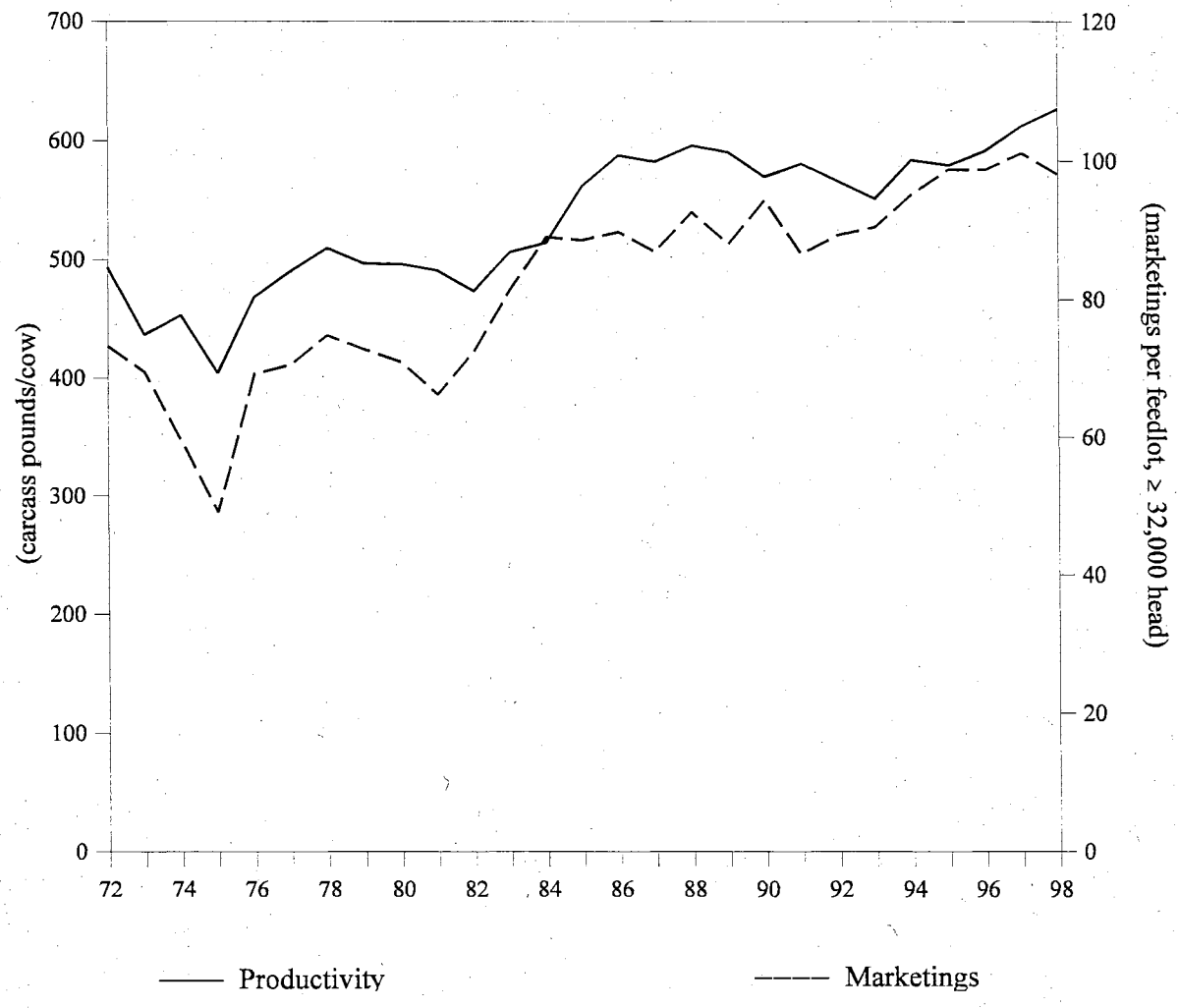
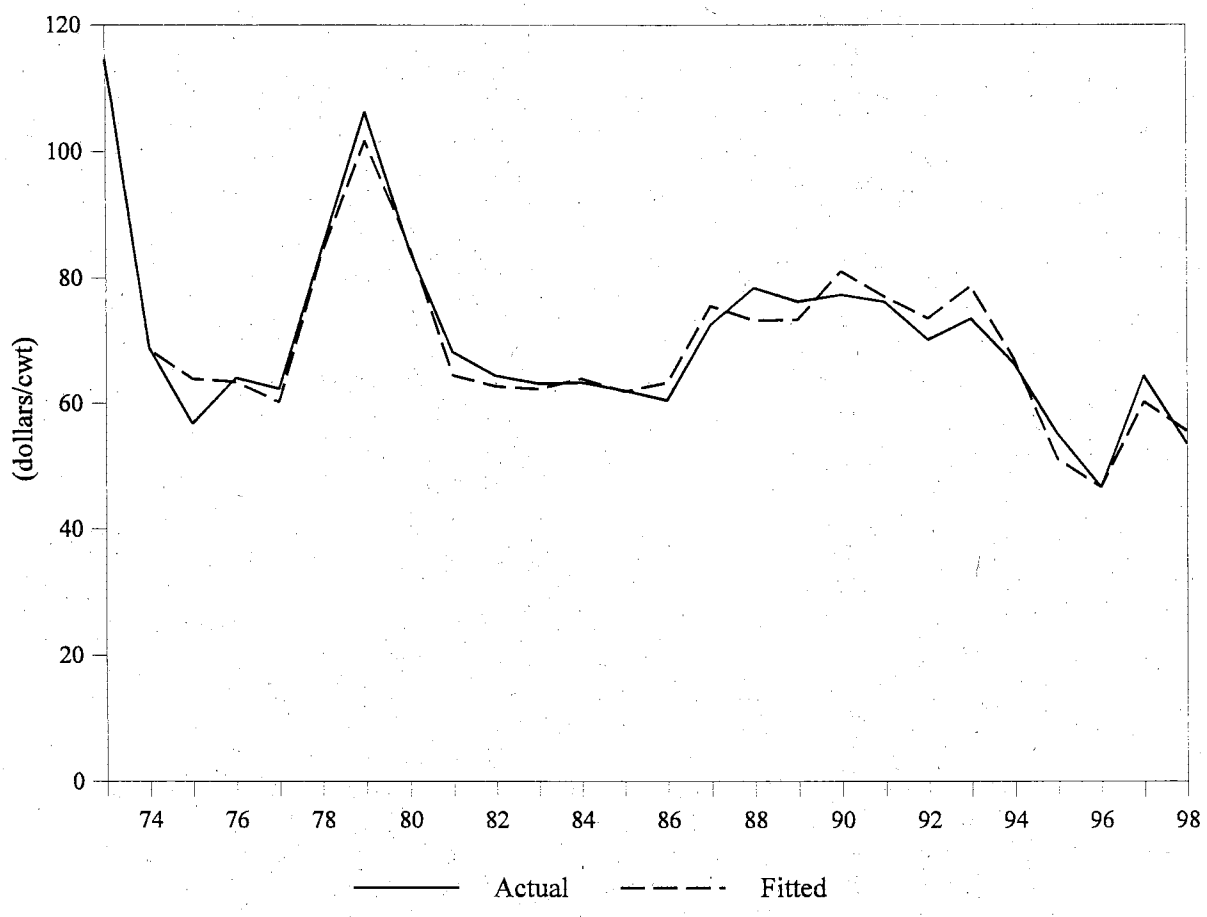


Figure 4. Observed and Predicted Values of Real Feeder Steer Price



Root Mean Squared Error = 3.161
Theil Inequality Coefficient = .022

Table 1. Estimated Changes in Real Feeder Steer Price Due to Volatility in Market Variables

Regressor	Flexibility	$Sx/\bar{x}$	Percentage	Price Impact ($/cwt)
Price Corn (P_m)	-0.278	0.383	0.106	7.58
Price Slaughter (P_s)	1.576	0.185	0.292	20.89
Feeder Supplies (Q_f)	-1.782	0.083	0.148	10.59
Interest Rate (I)	-0.072	0.360	0.026	1.86
Price Hay (P_h)	0.221	0.146	0.032	2.29
Market Risk (R)	-0.149	0.223	0.033	2.38
Productivity (T_f)	0.300	0.183	0.055	3.94
Productivity (T_p)	-0.700	0.111	0.078	5.58
Feeder Imports	-1.782	0.460	0.015	1.07

Notes: The Flexibility column (column 2) is the price flexibility coefficient for each variable estimated in equation (6); the $Sx/\bar{x}$ column is one standard deviation of the x regressor divided by its sample mean; the Percentage column is the percentage change in real feeder price due to regressor volatility (column 2 multiplied column 3, signs ignored), and the Price Impact column is the dollar/cwt change in real feeder steer price (column 4 multiplied by sample mean of $71.55/cwt). The bottom row of Feeder Imports is Mexican and Canadian feeder cattle imports. Their $Sx/\bar{x}$ calculation (0.46) is the standard deviation of feeder imports divided by the mean of feeder imports. This number is multiplied by the following: the flexibility coefficient 1.782, the feeder cattle import percent of total U.S. feeder cattle supplies (0.018 or 1.8 percent), and real mean feeder price of $71.55/cwt to yield the price impact ($1.07/cwt) in the last column.

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