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Pass-Through in United States Beef Cattle Prices

Huan Zhao, Xiaodong Du, and David A. Hennessy

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Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Huan Zhao is a doctoral student in the Department of Economics at Iowa State University. Xiaodong Du is a postdoctoral research assistant in the Center for Agricultural and Rural Development (CARD) and Department of Economics at Iowa State University. David Hennessy is a professor in CARD and the Department of Economics at Iowa State University.

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Questions or comments about the contents of this paper should be directed to Xiaodong Du, 565 Heady Hall, Iowa State University, Ames, Iowa 50011-1070; Ph: (515) 294-8015; Fax: (515) 294-6336; E-mail: xdu@iastate.edu.

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Abstract

Feeder cattle are fattened to become fed live cattle six months later. The U.S. feeder cattle industry is intensively competitive, so that market efficiency suggests feeder cattle prices should fully reflect feed prices and information on future fed cattle prices. Employing a long time series (1979-2004) of feeder cattle futures, live cattle futures, and local corn prices, we test whether complete pass-through occurs. The results indicate that an increase of a dollar per hundred pounds in the live cattle price leads to an increase of approximately $1.48 per hundred pounds in the feeder cattle price in one month, about 93% of complete pass-through. The corresponding negative effect of a corn price increase is about 87% of complete pass-through. By contrast with agricultural land markets, the results support the hypothesis of Ricardian rent extraction by the scarce asset owner in feeder cattle markets. The results also provide evidence in favor of informational efficiency in futures markets.

Keywords: feeder cattle, futures market efficiency, live cattle, structural change.

JEL Classification: D4; Q13.

1 Introduction

The beef industry is a large and significant sector in U.S. agriculture, with total production of 26.4 billion pounds in 2007. Sales of cattle and calves are approximately $61 billion, accounting for 21% of the total market value of U.S. agricultural products (Census of Agriculture 2007). In 2007, the 2,160 largest feedlots marketed approximately 12.1 million cattle, while another 2.7 million cattle were fed in 85,000 feedlots with capacities of less than 1,000 head (USDA 2009).

The beef animal production process in the United States is roughly as follows (Fields and Taylor 2006). Cows gestate for nine months and then care for their calves on grassland for approximately six months after birth. Upon weaning, calves can be retained for breeding, but the majority of female calves and almost all male calves enter feeder production systems. Typically, they are first backgrounded on cheap feed sources for several months. Feeder operators then purchase feeder cattle on the open market and use feed grain to fatten animals in feedlots during the months preceding slaughter. Feedlot cattle are fed predominantly high-energy cereal grain diets, mainly corn, during the finishing period. The intensive fattening process takes about 180 to 210 days, at the end of which the cattle are sold for slaughter.

An efficient system has evolved to support cattle movement since feedlots are both numerous and widely dispersed. It is reasonable to assume the feeder cattle market is perfectly competitive. Market supply is primarily determined by changes in the breeding herd and calf crop, occurring two years or more before slaughter. There is little one can do to accelerate the process of fattening an animal in order to take advantage of, say, high near-term prices. Breeding stock is the most limiting resource in beef cattle production. The time lag in production ensures a perfectly inelastic supply of feeder animals in the short run.

Inelastic supply implies that revenue fluctuations for feedlot operations resulting from high or low beef prices will ultimately accrue to cow-calf operators. In the well-integrated feeder and fed (live) cattle markets, changes in feed grain and fed cattle prices are expected to be completely passed through to those selling the immature feeder. The objective of this study is to test whether the sellers of feeder animals do receive the

“Ricardian” rent for ownership of an input that is both critical for production and in fixed supply.

In Ricardo’s original and classical application, the farmland rental market, land rent is the surplus that is generated from soil with higher productivity, and it is expropriated by the landlord (Ricardo 1821). Here, land is essential for production and is fixed in supply. Ricardian rent theory (RRT) has been tested in recent studies of farmland rents and prices. Du, Hennessy, and Edwards (2009) find some limited support for RRT when examining the effect of change in crop price on Iowa cropland cash rents (not crop share), where corn (maize) is the dominant crop. Their results indicate that cash rents increase by $96 to $100 per acre for a $1 increase in corn price in the long run, well below the $140 predicted by theory. A second test of the theory concerns government payments, whereby the government pays the producer. The producer is the tenant in a cash rent agreement and the owner whenever the owner farms the land. According to one interpretation of RRT, to whom the payment is given should not matter. Crop growing talent is not in scarce supply whereas suitable cropland is. Ricardo’s theory sees tenants bidding the rental price of land up until all of the government payment has been passed through to the land owner.

In seeking to quantify the impact of government subsidies on cash rents, several studies find incomplete pass-through. Lence and Mishra (2003) estimate that a $1 additional government payment pushes up cash rents by $0.13 per acre in 1996-2000. Utilizing the average of historical payments to represent expected government payments, Goodwin, Mishra, and Ortalo-Magné (2004) infer a $0.57 per acre increase in cash rents induced by an additional $1 in loan deficiency payments. Du, Hennessy, and Edwards (2009) find a long-term pass-through into cash rental rates of about $0.63 per acre for each $1 government payment. They attribute the failure of RRT to the lack of mobility of tenants and inertia in leasing contract re-negotiation. Kirwan (2009) concludes that only 25% of the government subsidy eventually flows to the landlord.

Based on very limited data regarding tenant density, Kirwan also suggests that imperfectly competitive rental markets may play a role in his findings. But there are other possible explanations, including acting on a belief in fairness when dividing additional surplus (Young and Burke 2001). Gneezy, List, and Wu (2006) provide evidence that

even the most basic tenets of economic rationality may be violated if the context obscures the logic. A large literature has emerged concerning the failure of the law of one price (Asplund and Friberg 2001). Evidence on pass-through in related markets would assist in refining why land rent market pass-through is incomplete.

Farmland is immobile while agricultural machinery is costly to transport. Tenants may not be mobile either, as many own land locally and operate out of their home farm yard. Efficiency has required larger and more expensive machines while genetically modified seeds and other innovations have enabled farmers to husband more acres. Farmers need to spread operation costs over a large acreage base in order to survive. Consequently, farmland rental markets are local, with a few nearby renters. When viewed this way, incomplete pass-through in land rental markets should be less surprising. A landlord is likely to have few potential tenants to bargain with.

The national cattle market is liquid, with comparatively low transportation costs. Typically, cattle born and grazed on rough land in western and southeastern states are shipped closer to the origin of concentrate feed in the lower Midwest and arid South. Cattle are traded in live auction barns and by video auctions as well as through forward contracts. These important distinctions between cattle and land markets suggest that reasons for the failure of RRT in land rent determination might not exist in beef cattle production.

By contrast with Ricardo's original application to land markets, the Ricardian rent concept may be appropriately applied to the feeder cattle market. At a feeder cattle auction, competitive buyers should bid the price up or down until the expected economic profit for feedlot operations is close to zero. No buyers would be willing to pay more for a head of feeder cattle than the difference between the expected fed cattle price and costs involved in feeding. On the other hand, competition should ensure that sellers will not accept prices less than total production cost. The determinants of feeder cattle prices are projected future prices for fed cattle, as well as input costs, mainly feed grain. Corn is one of the major feed inputs, accounting for more than 80% of all feed grains consumed by U.S. livestock (Ash 1994).

A related strand of the literature seeks to understand determinants of profitability in cattle finishing and also how feeder cattle prices are formed. Buccola (1980), Spahr

and Sawaya (1981), and Velez (2006) provide and apply a break-even method, commonly referred to as the cattle crush, for analyzing feeder cattle prices. This approach recognizes that the competitive zero economic profit assumption places a lower limit on the price bid for feeder cattle. Were price to fall below this level, then input and output forward markets could be used to arbitrage certain economic profit. Anderson and Trapp (2000) extend the framework to further quantify feeder cattle market responses to corn prices. Langemeier, Schroeder, and Mintert (1992) empirically estimate the impacts of prices and performance variables on feeder operation profits. Some other environmental factors such as facility design, sex, and placement weight are also found to be important in explaining cattle feeding profitability (Lawrence, Wang, and Loy 1999).

The issue of futures market efficiency has been investigated in a considerable body of literature. See reviews in Carter (1999), Williams (2001), and Garcia and Leuthold (2004). In an efficient futures market, prices should fully reflect available information at any time and provide an unbiased forecast of cash prices. In testing the forecasting ability of futures in cattle markets, various studies find that cattle futures prices are efficient predictors of cash prices for near maturity dates. For longer forecast horizons, the cattle markets do not perform as well as those for storable grains. They exhibit inefficiency and pricing biases (e.g., Leuthold 1972; Stein 1981; Garcia *et al.* 1988; McKenzie and Holt 2002).

This study contributes to the literature in three important ways. First, unlike the imposed break-even or zero profit assumption in previous studies, we directly test for zero economic profit. We do so by regressing feeder cattle prices on fed cattle and corn prices to ascertain whether changes in feeder cattle prices occur to offset changes in fed cattle and corn prices. Second, by re-examining cattle feeding profitability and pricing issues from the perspective of Ricardian rent theory, this study provides a better understanding of when the theory is likely to apply more generally. The third contribution of this study is to provide evidence on informational efficiency in futures markets as the futures prices of feeder and live cattle are employed in our empirical analysis. In the following section, we explain and describe the testable hypotheses.

2 The Hypotheses

Consider a feedlot operator who utilizes the futures market to lock in the expected live cattle price, buys feeder cattle and feed grain from local markets, and feeds the cattle to slaughter weight and grade. The net present value of expected profits per head for the feedlot operator (π) is

$$\pi_t = \frac{P_{t,T}^{fed} W^{fed}(1-D)}{1+r} - P_t^{feeder} W^{feeder} - P_t^C G^C - CO \tag{1}$$

where $P_{t,T}^{fed}$ is the time t expectation of the time T fed cattle price. This is represented by the time t price for time T maturity futures contract. Price P_t^{feeder} is the feeder cattle cash or nearby futures price at time t, W^{fed} represents the slaughter weight for fed cattle, and W^{feeder} represents the feeder cattle weight. Death loss, D, is expressed as a percentage of the total number of fed cattle. The discount factor for the six-month fattening process is given by r. The price and amount of feed grain, corn in this study, used to fatten the cattle are P_t^C and G^C, respectively. Symbol CO denotes other feeding and handling costs, which are small and are ignored in the following analysis. Setting profit in (1) to equal zero, i.e., $\pi_t = 0$, we impute a linear relation among feeder cattle, fed cattle, and corn prices. In what follows, futures cattle prices are expressed in dollars per hundred pounds following the futures contracts' specification of cents per pound.

By RRT, feeder cattle prices are bid up or down depending primarily on economic conditions in the cattle finishing operation, which implies the following testable hypotheses:

(i) A dollar increase in the fed cattle futures price, $P_{t,T}^{fed}$, should increase the feeder cattle cash or nearby futures price, P_t^{feeder}, by

$$\phi_1 = \frac{W^{fed}(1-D)}{W^{feeder}(1+r)} \text{ (dollars).} \tag{2}$$

(ii) A dollar increase in the corn cash price, P_t^C, impacts the feeder cattle price, P_t^{feeder}, by the amount of

$$\phi_2 = -\frac{G^C}{W^{feeder}} \text{ (dollars).} \tag{3}$$

Following the specification of the Chicago Mercantile Exchange (CME) for futures contracts, the midpoint weight of feeder cattle is 749.5 pounds, while it is 1,262.5 pounds for live cattle (CME 2009). These values are adopted for W^{feeder} and W^{fed}. Death loss D is considered to be 1%, which is the lower bound of the death rate in the feeding process reported in the literature.[1] We take 5% as the six-month discount rate and assume it takes about 50 bushels of corn to feed cattle to slaughter (ISU Extension 2009). So from equations (2) and (3), the two hypotheses are formally stated as

$$\begin{aligned} &H_0^{\text{feeder}}: \ \phi_1 = 1.59 \ \text{ vs. } \ H_a^{\text{feeder}}: \ \phi_1 \neq 1.59 \ \text{ and} \\ &H_0^{\text{grain}}: \ \phi_2 = 6.67 \ \text{ vs. } \ H_a^{\text{grain}}: \ \phi_2 \neq 6.67. \end{aligned} \tag{4}$$

3 Data and Estimation Results

Our empirical hypothesis testing makes use of monthly average settlement prices of the live cattle and feeder cattle futures contracts traded on the CME from January 1979 to February 2009. Monthly average corn prices are collected from the U.S. Department of Agriculture's monthly agricultural price reports (NASS 1979-2009). Feeder cattle futures prices, P_t^{feeder}, are taken from the nearest futures contracts at time t, which are the contracts closest to their expiration. The live cattle futures price, $P_{t,T}^{fed}$, is the price of the futures contract expiring six or seven months later, i.e., $T = t + 6 \text{ (or } 7)$. This number of months is chosen because (*a*) typically it takes six or seven months for an animal placed on feed to be finished; and (*b*) the live cattle futures contracts traded on CME are settled only in even months (February, April, June, August, October, and December). For

[1] The documented values of death rate range from 1% (Gilliam 1984) to 10% (Chavas 2000). Hoelscher (2009) reports that death loss ranged from 0.98% to 1.61% in May 2009. See Aadland and Bailey (2001) for a discussion. We note that a death loss assumption of more than 1% would further strengthen our primary findings.

simplicity, we assume that in even months it takes six months for cattle to be fattened, while in odd months the finishing process takes about seven months. Figure 1 presents the price series over the sample period.

Visual inspection of Figure 1 suggests the existence of a possible structural change between 2003 and 2004. Before that period all price series exhibited constant means and regular seasonal patterns, but prices appear to have trended upward with comparatively higher volatility afterwards. To verify the possible structural change and pin down its exact timing, we apply the structural change test proposed in Bai (1997). Timing of the structural change points are represented by the vertical lines in Figure 1. The results indicate that while the pattern of feeder cattle futures prices changed in July 2003, live cattle and corn prices had a structural change around April and August 2004, respectively.

It is interesting to note that the time gap is approximately time on feed, suggesting the feeder cattle market anticipated the structural change. A likely source of the structural change was the policy induced growth in demand for corn as an ethanol feedstock. The Renewable Fuel Standard (RFS), a provision of the Energy Policy Act of 2005, mandated a step-up schedule for mixing biofuels with gasoline over the 2006-2012 period. While the RFS was signed into law in August 2005, it is reasonable to expect that corn market participants anticipated an increase in demand for ethanol. To facilitate the empirical analysis, we restrict the sample period to January 1979 to April 2004 for all price series.[2]

To avoid spurious estimation, three unit root tests are applied on the time series over the chosen sample period, including the augmented Dickey-Fuller unit root test (Dickey and Fuller 1979), the Phillips-Perron unit root test (Phillips and Perron 1988), and the DF-GLS unit root test (Elliott, Rothenberg, and Stock 1996). The test results are presented in Table 1. Most of the test results reject the existence of a unit root in feeder cattle, live cattle, and corn price series, except for the Phillips-Perron test on feeder cattle price. We conclude that over the sample period all prices are mean stationary and that regular regression techniques on price levels are appropriate.

[2] Restricting the sample period to other periods suggested by the structural change tests, such as January 1979–July 2003 or January 1979–August 2004, does not change the results much.

After incorporating the observed seasonal pattern by monthly dummy variables, the empirical model can be established as

$$P_t^{feeder} = \alpha_0 + \beta_0 P_{t,T}^{fed} + \gamma_0 P_t^C + \sum_{k=1}^{11} d_k m_k + \varepsilon_t \tag{5}$$

where m_k $(k = 1,...,11)$ are the month dummies for January to November, while d_k $(k = 1,...,11)$ are the corresponding parameters. The impact of a dollar change in fed cattle and corn prices on feeder cattle price are represented by β_0 and γ_0, respectively.[3]

To allow for a possible dynamic effect of fed cattle and corn prices on feed cattle price, an extended model is considered as follows:

$$P_t^{feeder} = \alpha_0 + \sum_{i=0}^{p} \beta_i P_{t-i,T-i}^{fed} + \sum_{j=0}^{q} \gamma_i P_{t-j}^C + \sum_{k=1}^{11} d_k m_k + \varepsilon_t \tag{6}$$

where the total effect of fed cattle prices, ϕ_1, are reflected by $\sum_{i=0}^{p} \beta_i$ in model (6), while the effect of corn prices, ϕ_2, is equal to $\sum_{j=0}^{q} \gamma_j$. We select the number of lags included in the regression, p and q, such that adding additional lags does not significantly change the estimated total effect.

Table 2 presents the estimation results, in which column A presents the results of model (5). The low Durbin-Waston test statistics of 0.75 indicates autocorrelation among regression residuals, suggesting that the estimation results are misleading. To correct for the first-order autocorrelation, we apply the common Cochrane-Orcutt transformation in the Prais-Winsten regression model (Greene 2003, p. 273). After accounting for residual autocorrelation, the estimation results of models (5) and (6) are shown in columns B and C of Table 2. Note that in column C, the lag numbers are chosen as $p = 1$ and $q = 0$. Lagged corn prices are not included because the one-month lagged corn price has no significant effect on the dependent variable.

Compared with the results in column C of model (6), those in column B of model (5) present an incomplete explanation for the effect of the live cattle price on the feeder

[3] A test on seasonal differences in responses was also run, and the hypothesis that all responses were equal could not be rejected.

cattle price. After incorporating a one-month lagged live cattle price, model (6) significantly improves the model fitting, as adjusted R^2 increases from 0.40 to 0.68. The effect of a one-month lagged cattle price γ_1 $(= 0.503)$ is important both in terms of magnitude and in terms of its implication.

Together with the concurrent impact, the total effect of the live cattle price is about 1.479 (=0.976+0.503), which amounts to approximately 93% of the value hypothesized in the previous section. The immediate pass-through of corn prices to feeder cattle prices is about 5.833, which explains about 87% of the prediction in Section 2. From the statistical test results presented in Table 3, we fail to reject both null hypotheses at the 5% significance level, which provides evidence supporting the implication of RRT and complete price pass-through in beef cattle production. In addition, results in Table 2 indicate statistically significant seasonality components in feeder cattle prices during certain periods of time, including January, May, June, September, and October. The first-order autocorrelation coefficient in the error term is found to be significant and relatively high (0.74).

We can think of several reasons why complete price pass-through was not found in this study. First, the parameters used when indentifying complete pass through, such as animal weight, death rate, interest rate, and amount of feed grain required, are approximations and will differ across feedlots. Second, the corn price is used as the representative feed price. Including other feed prices such as soybeans or hay may lead to a slightly different estimate of total pass-through. But feed prices are highly correlated because of feed substitutability on the demand side and competition for acres on the supply side. Finally, while futures prices are used to represent the expected fed cattle price, measurement error may occur and statistical attenuation may bias the estimation coefficients toward zero (Greene 2003, p. 85).

4 Conclusion

Using a long time series (1979-2004) of feeder cattle, live cattle, and corn prices, this study provides evidence on complete pass-through of live cattle and feed grain prices to the feeder cattle price. The estimation results indicate that a change in the live cattle price of a dollar per hundred pounds leads to approximately 93% pass-through to the feeder

cattle price in about one month, while the corresponding negative effect of a corn price change of a dollar per bushel sees a similar but immediate pass-through.

This study also provides evidence in favor of Ricardian rent theory as it applies to live cattle markets. The evidence is in favor of informational efficiency in an agricultural market where the limiting critical input is mobile and trades are in a liquid market. The study also provides evidence in favor of futures market efficiency, as we employ live and feeder cattle futures prices in the empirical analysis. Regarding land markets, our findings suggest that a failure of rationality may not be the reason for low pass-through of crop prices and subsidies into land rents. Our work does not address the issue of participants seeking fairness in division of a change in surplus, where such pressures may be stronger in local land rental markets than in cattle markets. We are inclined toward one reason proffered in Kirwan (2009): land immobility and the bargaining power it provides local tenants. It will be challenging to test this hypothesis because surveys on land rent data do not generally provide details on the context surrounding bargaining over rent.

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Table 1 Unit Root Tests Results

	Feeder cattle	Live cattle	Corn
Augmented Dickey Fuller test	-2.886**	-2.779*	-4.097***
Phillips-Perron unit root test	-2.498	-2.879**	-2.711*
DF-GLS unit root test	-3.103**	-3.278**	-3.833***

Note: *, **, and *** denote that the null hypothesis of existence of unit root is rejected at the 10%, 5%, and 1% significance levels, respectively, while – denotes failure to reject the null. All tests include only a constant and lag 1 to correct for first-order autocorrelation.

Table 2 Regression Results

Variables	A	B	C
Live cattle price	1.552***	0.925***	0.976***
Lagged live cattle price	--	--	0.503***
Corn price	-6.417***	-4.756***	-5.833***
January	1.441*	1.008**	1.311***
February	0.521	0.240	0.604
March	0.349	0.074	0.380
April	-0.076	-0.518	-0.187
May	-1.778**	-1.789**	-1.291*
June	-1.439*	-1.390*	-1.218*
July	-1.169	-0.841	-0.768
August	-0.649	-0.101	-0.311
September	-3.162***	-1.869***	-2.296***
October	-3.880***	-2.455***	-3.475***
November	-1.216	-0.849*	-1.778***
Intercept	-13.348***	25.419***	-9.935**
1st order autocorrelation coefficient	--	0.89	0.74
Durbin-Watson test statistics	0.75	1.94	1.84
Adjusted R^2	0.9008	0.4030	0.6754

*, **, and *** denote rejection of the null hypothesis at the 10%, 5%, and 1% significance levels, respectively,

Table 3 Hypotheses Testing Results

Hypothesis	F test statistics	$P > F$
$H_0^{\text{feeder}}: \ \phi_1 = \beta_0 + \beta_1 = 1.59$	2.97	0.09
$H_0^{\text{grain}}: \ \phi_2 = \gamma_0 = 6.67$	1.21	0.23

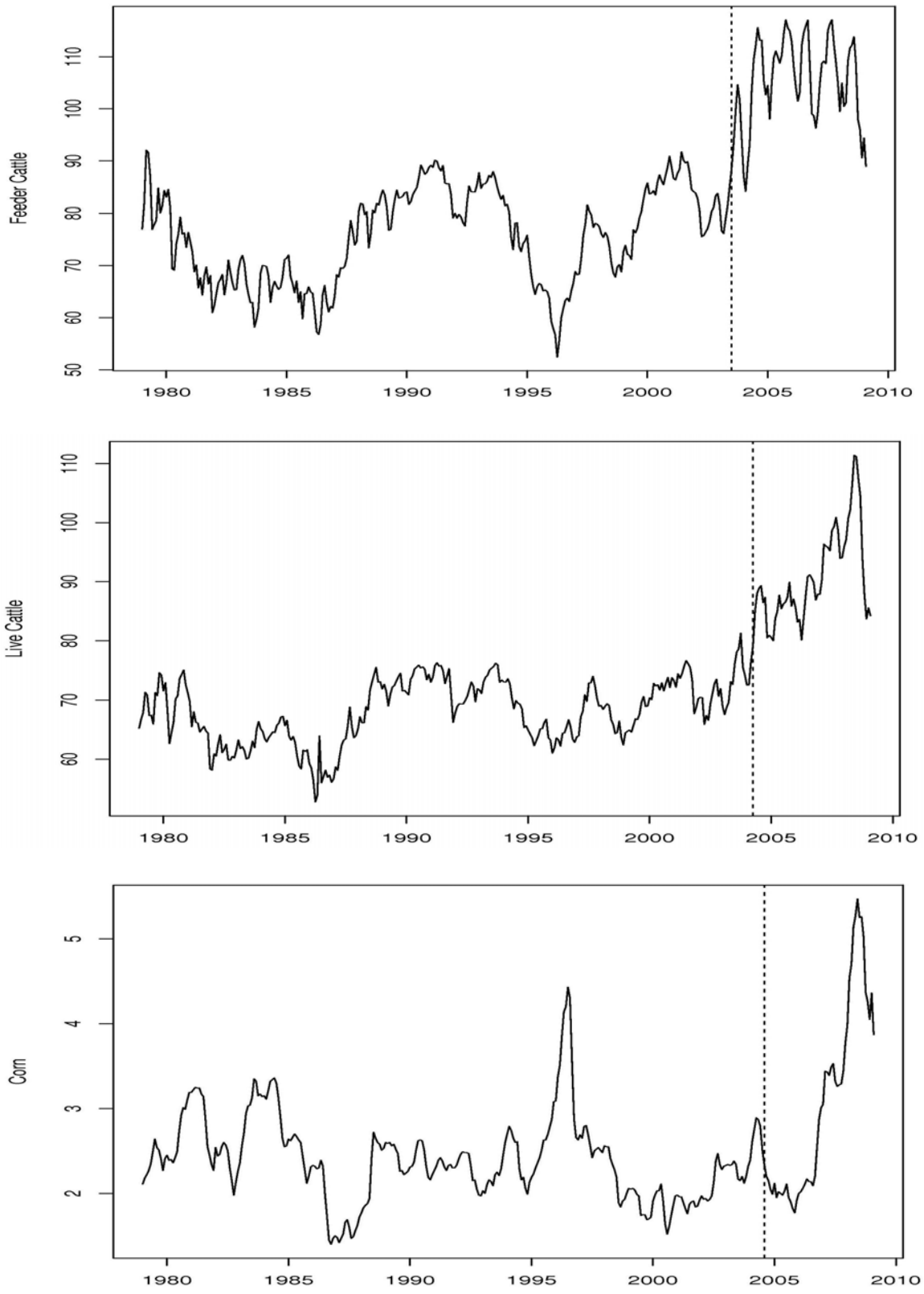

Figure 1 Monthly Average Prices and Structure Change Points in Feeder Cattle, Live Cattle, and Corn Prices, 01/1979–02/2009.