Market Coordination in the Beef Stocker Sector: Short and Long Run Implications of Higher Corn Prices

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Production and Marketing in the Beef Industry

A number of factors make the beef industry very complex. Among those are factors that directly relate to the basic production activities in the industry and marketing system functions that move the product from production to consumption (Peel, 2008). This paper presents a conceptual framework to understand market based coordination of production in the beef industry; the implications of the significant and permanent increase in corn prices in recent years; and how these forces will be manifest in price signals in the industry.

The primary production activity of the beef industry is the production of slaughter (fed) cattle that will produce carcasses with meat of desirable quality. However, this production usually occurs in multiple production sectors involving different producers in different locations. Many cattle pass through three production sectors of cow-calf; stocker and feedlot. Though separate, these production subsectors must be coordinated in the overall task of producing cattle ready for slaughter.

The cow-calf sector consists almost entirely of primary production activities. Cow-calf production combines forage resources and the breeding herd to produce calves that represent the feeder animal supply for all other industry sectors. The cow-calf sector controls the size of the cow herd and the production of feeder animals as well as replacement breeding animals. Most of the resources used in cow-calf production are long term in nature and the majority of costs for cow-calf production are essentially fixed in the short run. As a result most of the annual variation in returns to cow-calf production are due to variations in revenue, i.e. changes in the level of prices for calves.

The stocker sector provides both production and marketing value for the industry (Peel, 2003). The production value comes from providing additional weight gain and upgrading cattle quality to transform many calves from the cow-calf sector into feeder cattle as demanded by the feedlot sector. The stocker sector utilizes a wide variety of feed resources in mostly forage-based production systems and, along with the cow-calf sector, is the primary user of forage in the country. The stocker sector also

provides marketing value in the form of time and place utility. Stocker production provides much of the assembly of calves from widely dispersed, small cow-calf production operations into larger, more uniform lots of feeder cattle. Much of the general movement and concentration of feeder cattle in the central part of the U.S. occurs during stocker production. Stocker production typically varies from three to nine months in duration and provides considerable flexibility in the timing of feeder cattle in the market. Seasonally concentrated calf production is spread out by the stocker sector into more seasonally uniform feeder supplies for placement into feedlots.

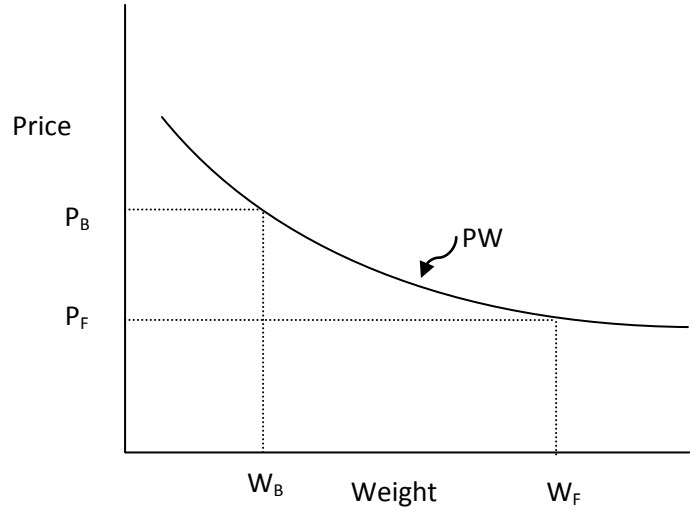
The fed cattle sector purchases feeder cattle which are finished in feedlots prior to slaughter. Feedlot demand for feeder cattle is derived from fed cattle values. In addition to feeder cattle, feedlots also utilize a large amount of grain as an input into finishing cattle. Changes in the price of feed will, for a given fed cattle price, change the demand for feeder cattle due to the changes in the profitability of cattle feeding. For example, higher grain prices suggest reduced demand for feeder cattle. However, feedlots can partially mitigate the impact of higher feed costs by increasing the size of feeder cattle placed in the feedlot.

In essence the feedlot can substitute more pounds of feeder cattle for the now more expensive feed. Heavier feeder cattle are produced with additional forage at the stocker level. And of course, since stockers and cow-calf production are the primary users of forage, these impacts of higher grain prices on the stocker sector may also impact the cow-calf sector in terms of forage allocation. Thus, while the beef industry has considerable flexibility to utilize variable proportions of forage and grain to maximize industry competitiveness, the ability to capitalize on this capability requires market coordination of distinct production sectors through appropriate market signals.

Price as Coordination Mechanism for the Beef Industry

The feeder cattle market that brings together the three beef cattle production sectors (cow-calf, stocker and feedlot) is depicted in Figures 1 and 2. As depicted in figure 1, feeder cattle markets consist of a constellation of prices for feeder cattle with weights ranging from lightweight weaned calves to heavyweight yearling feeder cattle. Of course, there are several related feeder cattle markets for various classes of feeder cattle of different qualities and gender but all are generally represented by Figure 1. Figure 1 shows that the price-weight relationship (PW) in feeder markets is, on average, a negatively sloped function that is convex to the origin. This reflects that fact that typically, the price per unit for feeder cattle is higher for lighter weights and decreases but at a decreasing rate for heavier animal weights.

Figure 1. Feeder Cattle Market Price Relationship to Animal Weight.



While Figure 1 depicts the typical or average feeder market situation, PW is subject to considerable variation under different market conditions. PW shifts up and down (intercept) according to overall feeder cattle price levels. Moreover, as shown in Figure 2, PW may vary widely in slope from sharply sloped to nearly horizontal and from nearly linear to sharply convex to the origin. Occasionally

the function will exhibit a discontinuous kink and under rare circumstances, PW can exhibit a positive slope, at least over a range of feeder weights.

Figure 2. Variation in Feeder Cattle Price-Weight Relationship.

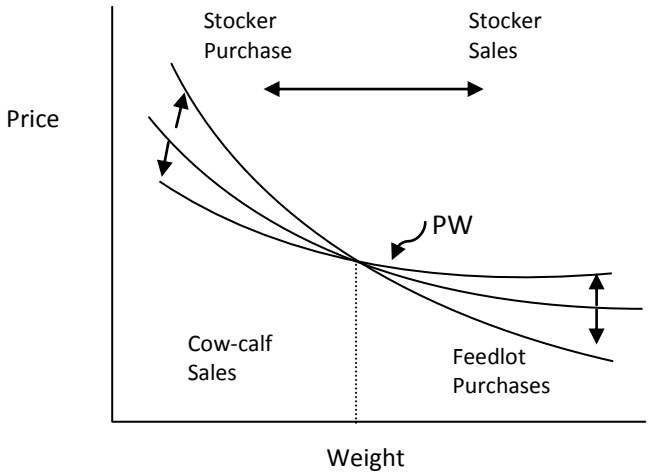


Figure 2 also depicts the relationship between cow-calf, stocker and feedlot production in the feeder market. Although feedlots occasionally purchase weaned calves directly from cow-calf production, in many cases, feedlots prefer feeder animals that are heavier (and older) than weaned calves. Stocker production links the cow-calf and feedlot sectors by providing a means to add weight and value to calves and provide the production and marketing values previously described (Peel, 2006).

Using Figure 1 as an example, weaned calves are sold from cow-calf production at weight W_B and price P_B. P_BW_B represents cow-calf revenue and also the initial purchase cost for stocker production. Feedlots purchase feeder cattle of W_F at a price of P_F. P_FW_F represents the per animal cost of feeder cattle purchased by the feedlot and also the final value of cattle sold from the stocker enterprise. The

economic incentives for stocker production are largely contained in the margin between the beginning value (cost) of animals purchased and the final value of animals sold as in 1):

1) $M = P_F W_F - P_B W_B,$

where M is the gross margin for stocker production; P_F is the final (selling) price of the animal; W_F is the final (selling) weight of the animal; P_B is the beginning (purchase) price of the animal; and W_B is the beginning (purchase) weight of the animal.

Final selling weight equals the beginning animal weight plus the amount of gain or gain can be expressed as the difference between final weight and beginning weight as in 2):

2) $G = W_F - W_B,$

where G is the total weight gain of the animal during the stocker enterprise.

A variety of stocker enterprises may be defined by different combinations of beginning weight and ending weight, which together represent different amounts of total gain. Each of these factors has a unique impact on the gross margin of the stocker enterprise. A convenient way to combine the impacts of beginning weight, ending weight and total gain is to calculate the value of gain for various potential stocker enterprises. The marginal value of gain is the gross margin divided by the total weight gain and is given by 3)[1]:

3) $V = \frac{M}{G},$

where V is the value per pound of gain. Substituting equations 1) and 2) into 3), the value of gain is given by:

3a) $V = \frac{P_F W_F - P_B W_B}{W_F - W_B}.$

Equation 3a) can also be written as:

[1] There is a technical distinction between marginal value of gain and average marginal value of gain as explained in Peel, 2006. The distinction is important in the optimization of a particular stocker enterprise. However, the general concept of marginality is the important consideration in this discussion so the technical distinction will be ignored.

3b) $V = P_F + \frac{W_B(P_F - P_B)}{W_F - W_B}$.

Equation 3b) provides insight into that factors that affect the value of stocker and the impacts of changes in those factors. In general, the value of gain, V, is the sum of two terms, the final price, P_F, and a second term. In the second term, $W_B > 0$; $(W_F - W_B) > 0$ and usually $(P_F - P_B) < 0$ meaning that the second term is usually negative. Thus, the value of stocker gain is usually smaller than the final price level. Intuitively, the value of gain is equal to the final selling price adjusted for the fact that there is a loss on the initial animal value. Since the final price is less than the beginning price, there is a loss equal to the difference in the two prices multiplied by the initial weight. This loss is depicted in the second term in 3b), adjusted to a per-pound of gain basis.

All of the factors in 3b) are related to each other (as in WP in Figure 1) so that a change in any one factor often implies simultaneous changes in one or more of the other factors in the equation. Changes in the intercept and slope of PW will determine the resulting value of gain according to the particular relationship between prices and weights. Nevertheless, a ceteris paribus evaluation of the factors in the equation is instructive.

- An increase (decrease) in final price (P_F) implies an increase (decrease) in V. The first term of 3b) is directly related to changes in the final feeder price, for example an increase in overall feeder cattle prices. Ceteris paribus, an increase in P_F also implies a smaller negative second term in 3b. However, higher P_F may be related to a higher beginning price as well, so the impact on the second term is uncertain.[2] Nevertheless, an increase in P_F usually results in an increased value of gain.
- A decrease (increase) in beginning weight (W_B) implies an increase (decrease) in V. Ceteris paribus, a smaller beginning weight means that there are fewer pounds over which to take the

[2] Stocker production is a biological process that takes time meaning that there is a time lag between the initial purchase at P_B and the sale at P_F. The correlation between the beginning and final price is therefore less direct than for a general change in feeder prices at a point in time. The impact of time is discussed later in the paper.

loss of the price difference ($P_F - P_B$). Additionally, a smaller beginning weight implies a larger total gain thus increasing the value of the denominator in the second term of 3b) and reducing the value of the second term. However, a smaller beginning weight is usually associated with a higher beginning price (P_B) so the loss per pound is bigger. Thus, the overall effect of changing the beginning weight depends on the particular relationship between beginning weight (W_B) and beginning price (P_B). With respect to the price difference ($P_F - P_B$), a smaller the slope of PW (Figure 1), reduces the negative term and increases the value of gain (V).

- A lower (higher) beginning price (P_B) implies a higher (lower) value of gain (V). Obviously, paying less for the animal will, ceteris paribus, reduce the loss on initial pounds, reducing the second term leading to an increase in V. However, as noted above, beginning and final prices may be positively correlated so a lower beginning price may be associated with a lower final price and the impact on value of gain is uncertain.
- An increase in the final weight (W_F) or indeed any increase in total gain (G), increases the denominator of the second term thereby reducing the negative impact of the term. Ceteris paribus, this means that increasing total gain likely increases the value of gain. However, a greater difference in beginning and final weight typically implies a bigger difference in the beginning and final price ($P_F - P_B$), again making the impact on value of gain uncertain.

There are several additional factors that affect the economics of stocker production as well. The time lag between purchase and sale of the animals allows for changes in overall market prices that can either enhance or diminish the value of gain. Equation 3c) shows how time is explicitly incorporated into Equation 3b):

3c) $V = P_{F,t+n} + \frac{W_{B,t}(P_{F,t+n} - P_{B,t})}{W_{F,t+n} - W_{B,t}}$.

Where t = initial date and n equals number of days of the stocker enterprise. The time lag between purchase and sales depends on the total amount of gain desired and the average daily gain (ADG) of the

animals, which in turn depends on the type of stocker production system and the quality of the animals. The total gain is thus a function of the length of time (n) and animal performance (ADG) as in:

4) $G = ADG * n$.

Using 4) rather than 2), equation 3b) can be rewritten as:

3d) $V = P_F + \frac{W_B(P_F - P_B)}{ADG*n}$.

Equation 3d) illustrates how production characteristics of the stocker enterprise, including animal performance (ADG) and length of time (n), directly impact the value of gain and thus the economic incentives for stocker production. Equation 3d) also demonstrates that production and marketing are intertwined and inseparable in the beef industry in a manner that is unique among all agricultural industries. In most agricultural industries, market conditions primarily drive decisions about whether to produce the product or changes in the level of production. However, in the beef industry, market conditions also provide considerable influence on how to produce. The stocker sector captures much of the beef industry's flexibility to adjust production systems in the short and long run and fundamentally change the industry's relative use of forage versus grain in the production of beef.

Stocker production encompasses a wide variety of production possibilities. A specific stocker enterprise depends on the choice of many factors including:

- ✓ Beginning weight
- ✓ Final weight
- ✓ Total Gain
- ✓ Rate of Gain
- ✓ Length of Time
- ✓ Quality of Animals
- ✓ Animal Gender

The choice of these factors that maximizes profit potential for a particular stocker enterprise depends on market conditions, i.e. stocker beginning and final prices and the producer's management and production constraints.

Lessons from History

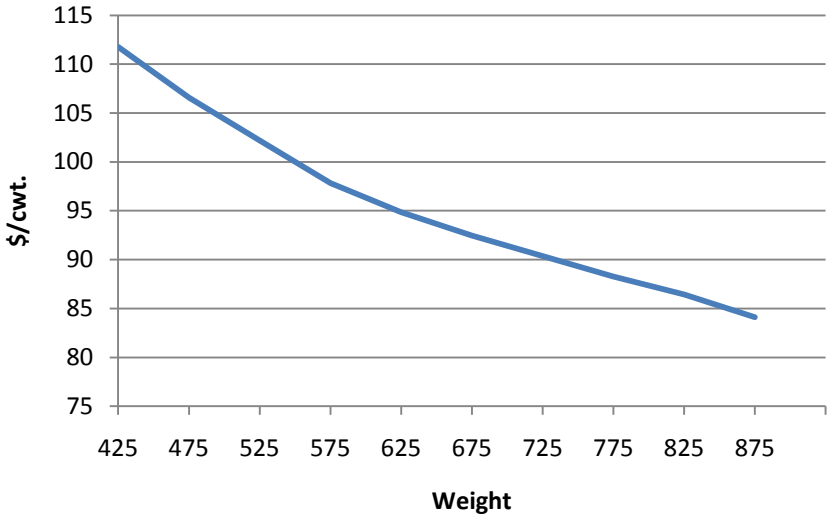
Average steer prices by weight for the 19 year period from 1992-2010 are presented in Table 1 and Figure 3. Figure 3 confirms that feeder cattle prices by weight generally have the relationship suggested in Figure 1 in that price per unit ($/cwt.) tends to be lower as animal weight increases. Closer examination of the price changes across weights shows that the rate of decrease in price by weight decreases for all but one weight category (Table 1), indicating that Figure 3 is convex to the origin across most of the range of weights.

Table 1. Feeder Steer Price*, Weekly, January 1992 – December 2010.

Weight (lbs)	Average Price ($/cwt.)	Change from Previous Weight Group ($/cwt.)	Price Change Per Pound ($)
425	111.76		
475	106.57	-5.19	-0.104
525	102.18	-4.39	-0.088
575	97.82	-4.36	-0.087
625	94.86	-2.96	-0.059
675	92.47	-2.39	-0.048
725	90.35	-2.11	-0.042
775	88.27	-2.08	-0.042
825	86.42	-1.85	-0.037
875	84.10	-2.32	-0.047

*Medium/Large, No. 1, Oklahoma City
Source: Livestock Marketing Information Center from USDA-AMS data

Figure 3. Feeder Steer Prices, Oklahoma City, Weekly Average, 1992-2010



Combinations of beginning weights, lengths of time and rates of gain result in a variety of possible stocker enterprises. Values of gain were calculated for a variety of stocker programs using equation 3c) and weekly data for each week from January 1992 through December 2009. The value of gain is an ex-post evaluation in that each week is treated as the beginning of a new stocker enterprise and the appropriate final weight and final price are used some weeks later according to the assumptions about length of time and average daily gain. The average value of gain for several combinations of beginning weight, length of time and average daily gain (which imply the total gain and thus final weight) are shown in Table 2. For example, a stocker enterprise that uses a 475 pound steer as a beginning weight, with an average daily gain of 2.10 pounds and a total gain of 250 pounds over a 17 week period has an average value of gain of $0.601/pound. This assumes that such an enterprise is initiated every week across all years.

Table 2 includes the average value of gain for 36 unique stocker programs with various combinations of beginning weight, rate of gain and length of time. Remarkably, the average value of gain is very consistent across all stocker programs, varying from a minimum average of $0.585/pound to a maximum average of $0.620/pound, and with 30 of the 36 programs having an average value between

$0.59/pound and $0.61/pound. The results suggest that over a long period of time there is no significant difference in the economic potential of a wide variety of stocker programs. These results are not surprising and, in fact, are to be expected if feeder cattle markets are efficient. Any differences in the average value of gain should be arbitraged away as long as the markets are efficient on average.

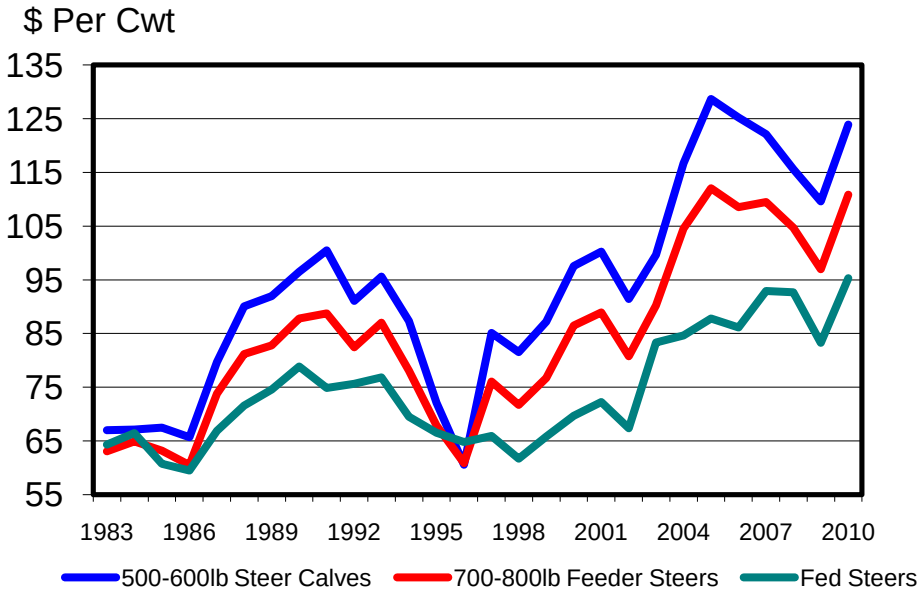
Table 2. Stocker Value of Gain, Weekly, 1992-2009, ($/lb.)^

		Weeks									
Weight Gain	Beg. Weight	12	15	16	17	18	19	20	22	23	24
200 lbs	ADG>>	2.38		1.79		1.58		1.43			
	475	0.585		0.593		0.596		0.601			
	525	0.592		0.600		0.605		0.607			
	575	0.605		0.614		0.617		0.620			
	625	0.601		0.610		0.611		0.613			
250 lbs	ADG>>		2.38		2.10		1.88			1.55	
	475		0.598		0.601		0.603			0.605	
	525		0.594		0.598		0.600			0.603	
	575		0.604		0.607		0.609			0.609	
300 lbs	ADG>>					2.38		2.14	1.95		1.55
	475					0.596		0.599	0.601		0.601
	525					0.594		0.597	0.596		0.596

^Based on Steers, Medium/Large, No 1, Oklahoma City

However, feeder cattle price levels and the relationship of prices by weight varies tremendously over time (Figure 4). Thus, the average values of gain in Table 2 mask a great deal of short run variation in values of gain under variable market conditions. The arbitrage that efficiently averages out differences across various stocker programs is a continuous process that depends on producers recognizing and responding to variable signals for different stocker programs at different points in time. The following sections will use two specific points in history to demonstrate the range of variability of stocker market signals under various cattle and feed market conditions.

Figure 4. Cattle Prices, Annual Average, 1983-2010



Source: Livestock Marketing Information Center

2005: Cattle Cycles and High Cattle Prices

The cattle industry has been characterized for many years by cycles of inventory and corresponding cycles of prices. Figure 4 includes cyclically low prices in the mid 1980s and mid 1990s and cyclically high prices in the early 1990s and again in the mid 2000s. April, 2005 was typical of the situation at the high price part of cattle cycles up to that time. Cattle inventories had bottomed and were beginning to expand in response to high cattle prices; beef production was squeezed by the overall low cattle inventory and the retention of heifers for herd rebuilding; and corn prices were low (see 2004 crop year price in Figure 5). Incentives for the various sectors can be summed as follows:

- Cow-Calf: rebuild the herd and increase calf production

- Stocker: Move cattle to feedlots without delay to facilitate maximum production with low inventories

- Feedlot: Utilize cheap grain to finish cattle quickly; to reduce age at slaughter by placing lightweight animals.

This situation represents the beef industry at maximum intensity moving animals through the system quickly and using relatively less forage and more grain. These signals are reflected in the values of gain in Table 3. The highest value of gain is for the lightest beginning weight and least amount of gain to move into feedlots more quickly and at higher weights. There are lower values of gain for owning animals longer (more total gain) or beginning at heavier weights.

Table 3. Steer Price, Total Value and Value of Gain, April 2005, Oklahoma City.

Weight (lbs)	Average Price ($/cwt.)	Total Value ($/head)	Value of Gain 425 lb. Beg. Weight ($/lb.)	Value of Gain 525 lb. Beg. Weight ($/lb.)	Value of Gain 625 lb. Beg. Weight ($/lb.)
425	154.75	657.69			
475	143.10	679.73			
525	137.43	721.51			
575	130.48	750.26			
625	126.92	793.25	0.678		
675	122.02	823.64	0.664		
725	116.14	842.02	0.614	0.603	
775	111.29	862.50	0.585	0.564	
825	107.46	886.55	0.572	0.550	0.467
875	104.74	916.48			0.493
925	103.09	953.58			0.534

1996: Low Cattle Prices and High Grain Prices

Cattle prices were cyclically low in 1996 (Figure 4) which typically leads to a situation where there is less variation in cattle prices by weight. The situation in 1996 was unique in that it was also a year of high corn prices, the result of drought (see Figure 5, 1995 crop year prices). The cattle industry situation was one of excess production; a need to reduce cattle inventories; and high feedlot cost of production and a need to reduce grain use in response to lower grain supplies. The result was a cattle market situation where prices were low in absolute levels and exhibited little variation across weights

(Table 3). Relative to Figure 1, this is a situation where the PW line has a smaller slope than normal. The incentives for the various sectors are as follows:

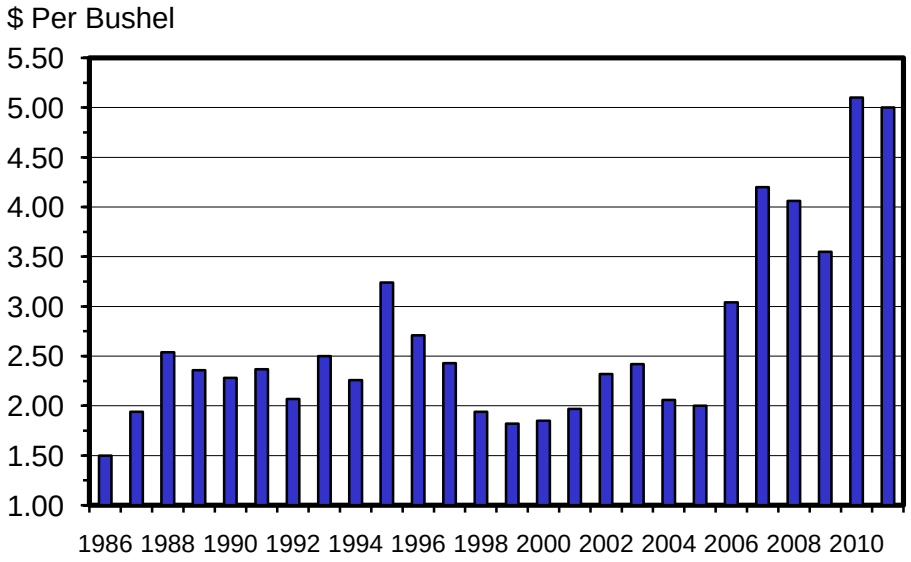
- Cow-Calf: liquidate cows and reduce calf production (use less forage for cow-calf production),

- Stockers: Use more forage for stocker based production, slow down the movement of cattle through the system and increase the average size of feeder cattle entering the feedlot,

- Feedlot: use less grain by placing cattle at heavier weights.

Generally low cattle prices encourage the cow-calf sector to reduce calf production. However, notice in Table 4, that the value of stocker gain is high relative to the general cattle price level. Thus, there is a relative signal to use more forage for stocker production compared to cow-calf production. Moreover, there is much less specificity in the stocker signals for various beginning weights and amounts of gain in Table 4, compared to Table 3. Comparing the situation in Table 3 to Table 4, calf prices have dropped by more than 50 percent while stocker value of gain has only dropped roughly one-third.

Figure 5. National Average Corn Price, Crop Year, Received by Farmers.



Source: Livestock Marketing Information Center

Table 4. Steer Price, Total Value and Value of Gain, April 1996, Oklahoma City.

Weight (lbs)	Average Price ($/cwt.)	Total Value ($50/head)	Value of Gain 425 lb. Beg. Weight ($/lb.)	Value of Gain 525 lb. Beg. Weight ($/lb.)	Value of Gain 625 lb. Beg. Weight ($/lb.)
425	63.60	270.30			
475	62.16	295.26			
525	59.57	312.74			
575	58.31	335.28			
625	57.19	357.44	0.436		
675	55.72	376.11	0.423		
725	54.13	392.44	0.407	0.399	
775	53.94	418.04	0.422	0.421	
825	53.13	438.32	0.420	0.419	0.404
875	52.47	459.11			0.407
925	51.19	473.51			0.387

Impacts of Permanently Higher Corn Prices

The dramatic and permanent increase in corn prices since 2006 (Figure 5) has both long and short run implications for the beef industry. In the short run, the primary way for the feedlot sector to minimize the negative impact of high corn prices is to place heavier cattle in the feedlot and reduce total corn use per animal, much as the industry did in 1996. Indeed, current cattle prices show that for the heavier weight feeder cattle, the price pattern is similar to that of 1996, although prices are currently about double 1996 levels in absolute value (Table 5). Thus the value of gain favors adding additional weight to stocker animals and is an incentive to use more forage for stocker production.

However, the industry currently has extremely low cattle inventories and is facing cyclical incentives to rebuild the herd and increase calf production. The market is attempting to provide incentives for cow-calf producers to rebuild the herd and increase calf production. This results in high prices for the lightweight feeder cattle in Table 5. The result is a rather unusual price weight relationship that is steep at lighter weights and flatter for heavy weights. The highest stocker value of

gain in Table 5 is for heavy beginning weights. The lowest value of gain is with the lightest beginning weights although the value of gain increases as the total amount of gain increases.

The most recent data reveals this situation even more obviously. Figure 6 shows prices in early January, 2011 compared to the previously described situations in 2005 and 1996. The current situation is a mixture of the high price incentives for calves similar to 2005 while price relationships for heavy steers is more similar to the situation in 1996. The cattle market situation now is unique in two respects. First, the market is trying to simultaneously encourage increased calf production and increased stocker production. This the first time the industry has faced low cattle inventories and high corn prices at the same time. Secondly, unlike previous occurrences, corn prices appear to be permanently higher on average. High corn prices have occurred at times in the past but were usually the result of supply reductions that were resolved in a matter of a few weeks or months. Increased demand for corn and other crops is likely permanent and, while the market continues to provide incentives for short term adjustments such as higher feedlot placement weights, more permanent structural change in the beef industry is implied. Over time the industry will likely adjust to fundamentally different production systems that emphasize forage use relative to grain use compared to current production systems.

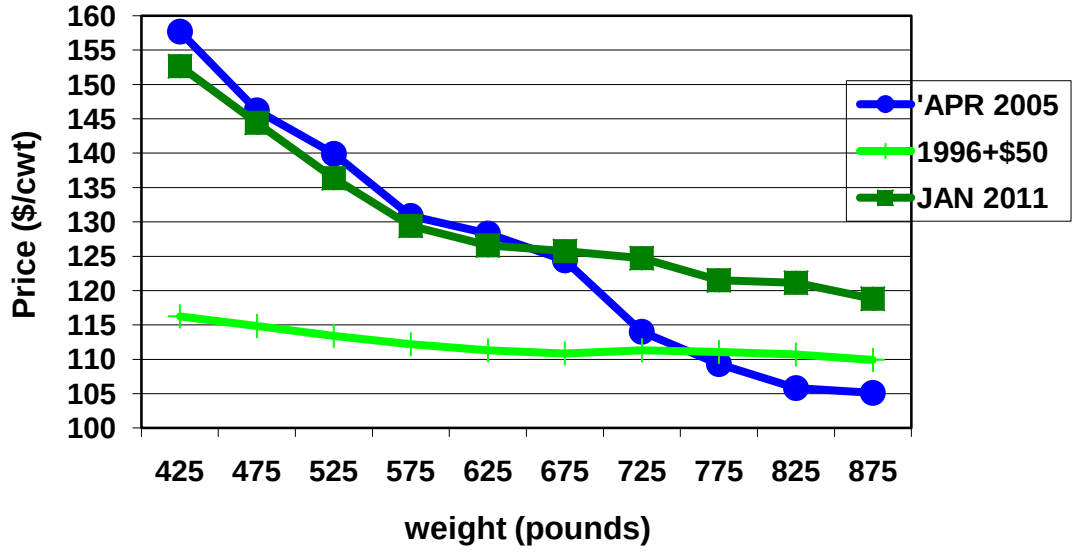
Summary

The complex set of beef industry sectors are coordinated by a relatively subtle combination of absolute price levels and price relationships across feeder cattle weights. The market is challenged not only to provide signals to increase or decrease overall production but also to change production systems in the short run to change the timing of cattle production; the allocation of forage between cow-calf and stocker production; and the overall balance of forage relative to grain use in the industry. Permanently higher corn prices have already been reflected in short term signals to adjust forage and grain use in the industry. These will likely continue and ultimately result in long structural change in production systems that favor an increase in forage relative to grain use in the industry.

Table 5. Steer Price, Total Value and Value of Gain, October 2010, Oklahoma City.

Weight (lbs)	Average Price ($/cwt.)	Total Value ($50/head)	Value of Gain 425 lb. Beg. Weight ($/lb.)	Value of Gain 525 lb. Beg. Weight ($/lb.)	Value of Gain 625 lb. Beg. Weight ($/lb.)
425	128.48	546.04			
475	125.17	594.56			
525	118.82	623.81			
575	114.47	658.20			
625	113.54	709.63	0.818		
675	111.80	754.65	0.834		
725	111.57	808.88	0.876	0.925	
775	110.04	852.81	0.876	0.917	
825	109.00	899.25	0.883	0.918	0.948
875	106.75	934.06			0.898
925	104.37	965.42			0.853

Figure 6. Feeder Cattle Prices, Oklahoma City.



Prices for 1996 have been scaled up by $50/cwt for comparison.

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