Dynamics of Feeder Cattle Basis and Price Slides

Kole Swanser

Ph.D. Candidate

North Carolina State University

kswanse@ncsu.edu

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Abstract

This study examines the dynamics of the relationship between per pound prices for feeder cattle at different sale weights. The feeder cattle "price slide" relationship, as it is commonly known, is influenced by fluctuations in the output price for slaughter cattle and the input price of feed corn. I empirically test predictions about price slide dynamics that are derived from a two-input derived demand model for slaughter cattle. Empirical analysis is conducted using an extensive dataset of feeder cattle transactions.

I. Introduction

Changing cattle prices contribute to fluctuations in the value of beef cattle and represent an important source of risk for all involved in the cattle industry. Futures markets can be useful for managing this risk only to the extent that cattle basis – defined as the difference between the per pound price for a standardized feeder cattle futures contract and the cash price for any specific group (lot) of cattle – can be understood and predicted. Two of the most important factors that influence feeder cattle prices and values are the price of finished cattle and the cost of feed inputs. The former represents output price – it measures the value of fed cattle that have reached a slaughter weight of around 1,250 pounds at the end of their production cycle. The latter represents the most substantial variable cost component of producing finished cattle from lighter feeder cattle.

Prices of standardized futures contracts for fed slaughter cattle and corn (a primary cattle feeding input) are determined almost continuously on the Chicago Mercantile Exchange (CME). In the same way that the value of a farmer's standing crop depends on current futures price for the commodity that can only be delivered after harvest, the value of a group of cattle today depends on fed cattle prices in the future, when those animals are ready for slaughter. After adjusting for time to slaughter, changes in fed cattle prices indicate changes in the expected ending value of lighter weight cattle. The impact of corn prices on the value of unfinished cattle is more complex. Changes in the cost of corn (a proxy for feed input cost) will have a disparate effect on cattle according to weight. Since lighter animals require more feed to reach finishing weight, the value of these animals is more sensitive to future feed costs. This has direct implications for the risk associated with owning cattle. Specifically, lightweight cattle are more exposed to value fluctuation resulting from corn price variability.

The fact that per pound prices for feeder cattle tend to decrease as sale weight increases is well-known to market observers and has been studied and documented by agricultural economists (Ehrich 1969, Buccola 1980, Marsh 1985, Dhuyvetter and Schroeder 2000). Within the cattle industry, this price-weight relationship is commonly called the "price slide." The slope of the price slide is heavily influenced by the price of the feed inputs that will be used to add weight to cattle. Constant changes in the shape of the cattle price slide reflect complex interactions between dynamic markets for feed inputs and fed cattle and other feeder cattle price determinants.   Previous researchers have even documented extreme market conditions when per pound prices for lightweight cattle have been discounted relative to heavier animals. These unusual periods when the market exhibits an "inverted price slide" correspond to very high corn prices relative to live cattle prices. Recent years have produced record high cattle and corn prices and significant price fluctuations. We have also seen the rising importance of ethanol production as a competing use for corn. These developments suggest that an updated analysis using extensive current data may yield additional insights about these market dynamics.

My analysis of cattle and corn price dynamics begins by first developing predictions about the relationship between futures price expectations and the cattle price slide using a two-input slaughter cattle production model within a simple derived demand framework. I then empirically test these predictions using a subset of data from a very large database of transaction-level feeder cattle sales. This working paper concludes with a discussion about intended areas of future research.

II. A Two-Input Derived Demand Model of Cattle Feeding

I generate predictions for the effects of cattle and corn prices on the slope of the price slide using a simple two-input derived demand model.[1] In this model, one finished steer for slaughter is produced by combining one steer weighing 200 lbs. to 1,250 lbs. with the requisite amount of a corn feed input.[2]   I make the simplifying assumption that cattle and corn are used in fixed proportions, and that the quantity of corn input required can be calculated directly based on the amount of weight gain required for the input steer to reach slaughter weight (assumed to be exactly 1,250 lbs.).

The value of the output good, one finished steer, is determined by the market price of live cattle. Factors that affect the market price of live cattle include the demand for live cattle, which

[1] Two futures contracts for beef cattle are traded on the CME (Chicago Mercantile Exchange). The feeder cattle contract (FC) is for 650-850 pound steers. The live cattle futures contract (LC) is for live steers that are "finished" (fed to the appropriate weight) and ready to be slaughtered. Although the live cattle contract does not specify a weight range, finished steers typically weigh around 1,250 lbs.

[2] A note on terminology is appropriate here. Curiously, there is no singular form of the word "cattle" in the English language that does not refer to a specific sex. Thus, I have chosen to use one feeder steer as the subject of my model illustration. Cattle that have not yet reached slaughter weight (approximately 1,250 lbs.) are typically called either feeder cattle (if 650 lbs. or heavier) or stocker cattle (if less than 650 lbs.). Feeder and stocker cattle are typically sold as either steers (castrated males) or heifers (females that have not yet given birth to a calf), although are bulls (males that have not been castrated) are commonly sold in some regions. The model presented here applies to heifers and bulls as well as steers.

is exogenous to the model, and the supply of live cattle. The beef production process is characterized by long biological lags. This means that the current supply of live cattle for slaughter is comprised of cattle that were born over 18 months earlier. Consequently, the future supply of live cattle can be predicted well in advance of delivery based on current cattle inventories. In this model I assume that cattle gain weight and progress through the beef production and feeding process at a known constant rate. Thus, the supply of cattle in any given weight group today will be equal to the supply of live cattle on the known future date when they will all reach 1,250 lbs. This implies that current cash cattle prices for lighter weight animals are linked to market conditions that are reflected in prices for heavier animals to be delivered in the future.

Derived demand for the steer input in the two-input model can be obtained by subtracting the cost of the corn feed input from the value of the finished 1,250 lb. steer output (following Friedman 1962, chapter 7). The difference between the total value of the finished steer and the total value of the input steer will be equal to the corn feed input cost. This difference is commonly known as the gross feeding margin (GFM).

Example Feeder Cattle Model Calculations

An example using specific values for production coefficients, prices, and input variables helps to illustrate the price slide relationship implied by the two-input derived demand model. Table 1 displays feed requirement and cost calculations for two different weights of input steer: a 750 lb. "feeder" and a 550 lb. "stocker." The calculations use a standard feed conversion factor – seven pounds of corn grain are required to produce one pound of steer weight gain.[3] Gray-shaded values for input and output weights and corn prices (set initially at $7.50/bushel) are considered to be exogenous. Since feed costs are linear with respect to weight, gross feeding margin (GFM) is proportional to the weight of the input steer and per pound cost of gain (COG) is equal for both steer types.

Derived values for the two weights of input steer are displayed in table 2. These are calculated by subtracting the expected gross feeding margin calculated in table 1 from the expected value of a finished 1,250 lb. steer. A live cattle futures price (LC1250) of $1.24 per pound is used to calculate slaughter value for both weights of cattle in this example.

[3] This conversion factor is common in the industry literature. See, for example, Anderson and Trapp 2000. Also note that one bushel of corn weighs 56 lbs.

Note that additional pounds of weight gain will always translate into greater value for heavier steers in the two-input derived demand model as long as cost of gain is non-zero. At the same time, we can see that the per pound price of a steer declines as sale weight increases. The empirical analysis focuses on dynamics of the per pound price-weight relationship (the cattle price slide).

Figure 1 plots calculated values from the two-input derived demand model over a spectrum of input steer weights ranging from 200 to 1,250 lbs. using example price and production input values. The required gross feeding margin declines with input weight starting from approximately $1,000 GFM for a 200 lb. steer input. Steer input value increases linearly at the same rate until steer input weight equals slaughter weight, GFM is zero, and the steer input value equals slaughter value (Value_1250). The implied per pound price for each weight of steer input is also plotted on the right vertical axis. Note that the model parameters used in this example produce a downward sloping price slide relationship with a convex curvature.

This numerical example is also useful for illustrating the effect of corn input price on both steer input value and the price slide. Figure 2 plots new model outputs calculated using identical values for all parameters except the corn price, which has been reduced from $7.50 to $3.50 per bushel. Holding all else equal, including the price of live cattle, a sharp reduction in the price of corn lowers the GFM and raises the value of the input steer at all weights. In addition, the slope of the price slide becomes steeper (more negative) over the entire range of input steer weights.

Figure 3 depicts a familiar representation of the derived demand model using supply and demand graphs. Here, V_{1250} represents the final output "price" (value per 1,250 lb. steer) that is determined at the intersection of supply and final output demand. Since the quantity of steers available for slaughter today were born months earlier and few alternative uses exist, the short-run supply is assumed to be fixed (vertical supply curve). The gross feeding margin can also be interpreted as the marginal cost or supply curve for the feed input, which I assume does not depend on the quantity of steers (horizontal marginal cost curve). The derived demand for steers as inputs can be obtained as the difference between the final output demand curve for 1,250 lb. steers and the supply curve for feed inputs.

Graphing derived demand relationships normally requires that the input and output goods be converted into equivalent units. However, in this case one unit of the steer input is necessarily equal to one unit of the slaughter steer output. Further, if we think of figure 3 as a timeless representation of derived demand for a single group of steers moving between weight ranges, then the supply of steer inputs at each weight must remain constant and equal to the final output supply of slaughter steers. Thus, the value (price per steer) of a steer input is determined at the intersection of a single vertical supply curve and a derived demand curve that corresponds to the input weight. Consistent with the previous example calculations, value per steer increases and per pound price decreases with steer input weight. The group of 550 lb. steers (valued at $893.75/steer and $1.63/lb.) in figure 3 will become the 750 lb. feeder steers (valued at $1,081.25/steer and $1.44/lb.) approximately three months later and become 1,250 lb. slaughter steers (valued at $1,550/steer and $1.24/lb.) in roughly one year. Analysis of cattle prices at different weights must therefore incorporate future price expectations for a particular weight cohort of cattle.

Predictions about the shape of the price slide that have been derived from this two-input derived demand model cannot be applied to a cross-section of prices for cattle of different weights at a given point in time. This is because supply and demand conditions are likely to vary for different cattle weight groups due to factors such as seasonality and cattle production trends. Differences in inventory for different steer weights will affect supply in the final slaughter steer output market and thus impact the derived demand price of steer inputs.

Figure 4 illustrates this point using separate derived demand markets for the 550 lb. stockers and 750 lb. feeder steer inputs. The market for 550 lb. steers shown on the left is identical to figure 3. However, the market shown in the panel on the right shows a larger supply of 750 lb. feeder steers. Both input and output prices for the 750 lb. steer are lower relative to the market conditions shown in figure 3 when a smaller quantity of steers was supplied. (For reference, the supply curve and prices from figure 3 are shown by dashed lines in figure 4.) Notice that the value of a 750 lb. feeder steer input in figure 4 is less than the value of the 550 lb. stocker steer. This results directly from the lower expected live cattle price for the weight cohort due to greater supply expectations.

This example clearly illustrates why a cross-section of prices for cattle of different sale weights at a given point in time need not necessarily exhibit a downward-sloping price slide relationship. Similar outcomes can be shown to result from differences in future demand for slaughter steers. Because live cattle futures prices depend on expected supply and demand conditions for a particular weight cohort of cattle, it will be important to link current cash transactions to appropriate future price expectations in the empirical analysis.

III. Empirical Predictions

I use the two-input derived demand model to generate empirical predictions related to the shape and dynamics of the price slide relationship. A mathematical representation of the model facilitates the derivation of comparative static relationships.[4] Recalling that the value of the output is comprised of the combined value of both inputs, we begin with the following expression:

$$\begin{aligned} Value_{1250} &= Value_{InputWt} + GFM_{InputWt} \\ P_{1250} * 1250 &= P_{InputWt} * InputWt + COG(1250 - InputWt) \end{aligned} \qquad (1)$$

I have assumed that the weight of the slaughter steer is fixed at exactly 1,250 lbs. as described previously. *InputWt* is the weight of the steer at the time it is sold as a feeder cattle input, and *P* always refers to a per pound price that is denoted by a subscript to identify the weight of cattle for which the price pertains. *COG* is per pound cost of gain, which I assume to be constant over all weight ranges and to depend only on the cost of the feed corn input, and *GFM* refers to gross feeding margin based on steer input weight. Rearranging this relationship gives us the price of the steer input in terms of known weights and exogenously determined output and corn prices.

$$P_{InputWt} = P_{1250}\left(\frac{1250}{InputWt}\right) - COG\left[\left(\frac{1250}{InputWt}\right) - 1\right] \qquad (2)$$

We further isolate the per pound price spread at different sale weights by expressing this relationship in terms of the difference between input and output prices:

$$\left(P_{InputWt} - P_{1250}\right) = \left(P_{1250} - COG\right)\left[\left(\frac{1250}{InputWt}\right) - 1\right] \qquad (3)$$

[4] The mathematical model used here to develop of empirical predictions is similar to those used by Buccola (1980) and Ehrich (1969).

Given that input steers must gain weight before slaughter and $InputWt < 1250$, we know that the term in brackets must be positive. Therefore, the model predicts that price of the lighter input steer will always be greater than the live cattle price ($P_{InputWt} > P_{1250}$) when per pound price of the output steer exceeds the marginal per pound cost of gain ($P_{1250} > COG$). This implies that the price slide will be negatively sloped (as expected) except in cases where feed costs become exceptionally high relative to live cattle prices.

For the empirical analysis I normalize the dependent variable to remove variation in overall price levels and focus more directly on differentials between prices for different weights of cattle. This normalization is accomplished by replacing the cash price of the input steer, $P_{InputWt}$, with basis to the feeder cattle contract, $Basis_{InputWt}^{750} = P_{InputWt} - P_{750}$. By substituting for the price of a 750 lb. steer and again rearranging the expression, I obtain the following equation for feeder cattle basis:

$$Basis_{InputWt}^{750} = \left(P_{InputWt} - P_{750}\right) = \left(P_{1250} - COG\right)\left[\left(\frac{750}{InputWt}\right) - 1\right]\left(\frac{1250}{750}\right) \qquad (4)$$

This basis equation relates directly to an empirical strategy that predicts basis as the dependent variable using sale weights, live cattle prices, and corn prices as explanatory variables. Empirical predictions can now be generated by deriving comparative statics from feeder cattle basis relationship. First derivatives with respect to the three explanatory variables are shown below.

$$\frac{\partial Basis_{InputWt}^{750}}{\partial InputWt} = -\left(P_{1250} - COG\right)\left(\frac{750}{InputWt^2}\right)\left(\frac{1250}{750}\right) \qquad \text{(negative*)} \qquad (5.a)$$

$$\frac{\partial Basis_{InputWt}^{750}}{\partial COG} = -\left[\left(\frac{750}{InputWt}\right) - 1\right]\left(\frac{1250}{750}\right) \qquad \text{(negative)} \qquad (5.b)$$

$$\frac{\partial Basis_{InputWt}^{750}}{\partial P_{1250}} = \left[\left(\frac{750}{InputWt}\right) - 1\right]\left(\frac{1250}{750}\right) \qquad \text{(positive)} \qquad (5.c)$$

The expected sign of each derivative is given in parentheses. Note that model predictions for the impact of both cost of gain (negative) and live cattle price (positive) on the magnitude of basis are unambiguous. However, the asterisk (*) next to the predicted sign of the first partial with respect to weight indicates that the slope of the price slide (expressed here in terms of basis) will be negative only when $P_{1250} > COG$.

As shown previously, our model implies a quadratic price slide relationship. Taking the second derivative with respect to weight allows us to sign the quadratic term.

$$\frac{\partial^2 Basis_{InputWt}^{750}}{\partial InputWt^2} = \left(P_{1250} - COG\right)\left(\frac{750}{InputWt^3}\right)\left(\frac{1250}{750}\right) \qquad \text{(positive*)} \qquad (6.a)$$

The positive expected sign of the expression in equation (6.a) suggests that the price slide will have a negative slope which becomes less negative (flattens) as weight of the input steer increases. Cross-partial derivatives with respect to weight and prices yield two additional predictions about dynamics of the price slide relationship that will be of particular interest for the empirical analysis.

$$\frac{\partial^2 Basis_{InputWt}^{750}}{\partial InputWt \cdot \partial COG} = COG\left(\frac{750}{InputWt^2}\right)\left(\frac{1250}{750}\right) \qquad \text{(positive)} \qquad (6.b)$$

$$\frac{\partial^2 Basis_{InputWt}^{750}}{\partial InputWt \cdot \partial P_{1250}} = -P_{1250}\left(\frac{750}{InputWt^2}\right)\left(\frac{1250}{750}\right) \qquad \text{(negative)} \qquad (6.c)$$

Two unambiguous model predictions are evident based on the sign of these expressions. First, an increase in *COG* will cause the slope of the price slide to flatten (become less negative). This implies that prices (and feeder cattle basis) for lighter weights of cattle will decline disproportionately relative to heavier cattle. Second, an increase in the expected live cattle output price will have the opposite effect: the slope of the price slide will increase as the prices of lighter cattle increase relative to prices of heavier cattle.

IV. Data

This analysis makes use of an extensive database of cash cattle transactions obtained from the USDA's Agricultural Marketing Service (AMS). The AMS feeder cattle data include information about all individual lots (sale groups) of cattle sold at hundreds of public auction locations in more than 20 states across the continental U.S. In its entirety, the database contains over 13 million sales transactions for cattle weighing between 300 and 900 pounds from 1996 to

2013. The cattle sold represent a variety of stages in the beef production process, from light stockers to heavy feeders, although buyer information and intended use is not available.

A subset extracted from the larger AMS dataset has been used to conduct the preliminary empirical analysis described in this working paper. The sample data contains 282,152 transactions from seven public auction locations in Kansas over a 10 year period. Each sales transaction record in the dataset contains the date of sale, cash price, and several individual lot characteristics. Lot characteristics about the group of cattle sold in each transaction include the sales location, number of cattle in the group (lot size), average weight, and sex of the cattle (steers, heifers, or bulls).

The AMS cash feeder cattle market data has been combined with CME futures price data. Relevant cattle futures contracts were identified for each group of cattle sold, and prices were linked to each transaction in the database. Sale date and average lot weight were used to establish the future dates on which cattle in each sale lot would be predicted to attain weights of 750 and 1,250 pounds assuming a constant rate of weight gain. These weights were chosen because they correspond to weight specifications for the feeder and live cattle futures contracts, respectively.

As a specific example, consider a lot of cattle sold on 10/1/2012 with an average weight of 550 lbs. Assuming average gain of 2 lbs. per day, these cattle would be expected to weigh 750 lbs. after 100 days on January 9, 2013. As of that date, the JAN2013 feeder cattle contract would be next to expire (nearby contract) on 1/31/2013. The same group of cattle would be expected to weigh 1,250 pounds after another 250 days ((1,250 lbs. – 750 lbs.) / 2 lbs./day) on 9/16/2013 when the OCT2013 live cattle contract would be next to expire on 10/31/2013. The observed daily settlement prices for these contracts on 10/1/2013 determine the values of feeder cattle and live cattle price variables for the cattle:

$FC750_{it}$	= Price of JAN2013 feeder cattle contract on 10/1/2012	= \$148.125 /cwt
$LC1250_{it}$	= Price of OCT2013 live cattle contract on 10/1/2012	= \$133.75 / cwt

These prices are subscripted for sale date *t* and individual lot *i*. They reflect the expected future supply and demand conditions for a specific group of cattle described in the sales transaction. In a broader sense, these are specific market price expectations for a single weight cohort of cattle that are assumed to reach slaughter weight at the same time. For empirical estimation, $FC750_{it}$ is used as the current estimate of P_{750} (the expected future price of the group of cattle at 750 lbs.) and $LC1250_{it}$ is used as the current estimate of P_{1250} (the expected future price of the group of cattle at 1,250 lbs.). Current basis is calculated using the feeder cattle contract reference price of $FC750_{it}$ for each cattle sales transaction as follows:

$$Basis_{it}^{750} = Cash_{it} - FC750_{it} \quad (7)$$

The current price of the nearby corn contract, $CN0_t$, proxies for feed input costs in the empirical model. For lighter weight animals, prices of deferred corn futures contracts (contracts expiring after the nearby) might also be considered. However, the nearby contract price was chosen as the best corn price expectation at all sale weights for two reasons: 1) remaining feed input requirements are easily forecast in advance based on the average weight of the group of cattle purchased, and 2) corn for grain is a storable commodity. Together, these imply that a cattle buyer will always have the option of purchasing the expected feed corn requirement at the same time as the cattle.

Table 4 displays summary statistics for the sample Kansas dataset that was used in the empirical analysis. These data span a period from January 6, 1999 to March 26, 2009 and include data for sale lots of feeder and stocker cattle weighing 300 to 900 pounds. The time period also included substantial variation in the prices of feeder cattle ($69.97 to $119.57 per cwt), live cattle ($60.67 to $117.70 per cwt), and corn ($1.75 to $7.61 per bushel). Feeder cattle basis in the sample data ranged from a low of -$63.62 (when cash price was lower than FC750) to a high of $87.33.

V. Estimation and Results

To test predictions developed from the two-input derived demand model, I estimate a hedonic regression of feeder cattle basis. My analysis focuses primarily on the price relationship between cattle basis and weight, as described previously. The basic regression specification in Model 1 below describes this relationship and accommodates an expected quadratic shape for the price slide.

Model 1: $Basis_{it}^{750} = a + b*Weight_{it} + c*Weight_{it}^2 + \varepsilon_{it}$

The expected shape of the price slide relationship from figures 1 and 2 suggest that *a* and *c* will be positive, while *b* should be negative. Our model also generated predictions about the relationship between basis and expected prices for the live cattle output and feed corn input. Model 2 gives another simple linear specification that includes these variables of interest:

Model 2: $Basis_{it}^{750} = a + b*Weight_{it} + c*Weight_{it}^{2} + d*CN0_{t} + e*LC1250_{it} + \varepsilon_{it}$

Comparative statics derived previously predicted that the sign on coefficient *d* will be negative and coefficient *e* will be positive. Parameter estimates for models 1 and 2 are shown in table 5. All four coefficients exhibit the predicted signs in both models and are highly significant (p-values < 0.0001).

Models 1 and 2 generate parameter estimates that can be easily interpreted and directly compared to model predictions. However, these simple specifications have some obvious limitations. In particular, they do not facilitate testing of any dynamic interaction between market prices and weight. To explore these relationships requires the introduction of additional interaction terms between weight and price. Model 3 allows the slope of the price slide to depend on expected corn and live cattle prices.

Model 3:

$$\begin{aligned} Basis_{it}^{750} &= a + d*CN0_{t} + e*LC1250_{it} \\ &\quad + \left(b + f*CN0_{t} + g*LC1250_{it}\right)*Weight_{it} \\ &\quad + \left(c + h*CN0_{t} + l*LC1250_{it}\right)*Weight_{it}^{2} + \varepsilon_{it} \\ &= a + b*Weight_{it} + c*Weight_{it}^{2} + d*CN0_{t} + e*LC1250_{it} \\ &\quad + f*CN0_{t}*Weight_{it} + g*LC1250_{it}*Weight_{it} \\ &\quad + h*CN0_{t}*Weight_{it}^{2} + l*LC1250_{it}*Weight_{it}^{2} + \varepsilon_{it} \end{aligned}$$

Interpreting the meaning of coefficients estimated from Model 3 within the context of previously derived predictions requires that we first take derivatives of the regression equation. First, second, and cross-partial derivatives of basis with respect to the independent variables of Model 3 are shown below, followed by their predicted signs.

First derivatives:

$$\frac{\partial Basis^{750}_{InputWt}}{\partial Weight} = \left(b + f * CN0_t + g * LC1250_{it}\right) + 2*\left(c + h*CN0_t + l*LC1250_{it}\right)*Weight_{it} \quad \text{(negative*)} \quad (8.a)$$

$$\frac{\partial Basis^{750}_{InputWt}}{\partial CN0_t} = d + f * Weight_{it} + h * Weight^2_{it} \quad \text{(negative)} \quad (8.b)$$

$$\frac{\partial Basis^{750}_{InputWt}}{\partial LC1250_{it}} = e + g * Weight_{it} + l * Weight^2_{it} \quad \text{(positive)} \quad (8.c)$$

Second and cross partial derivatives:

$$\frac{\partial^2 Basis^{750}_{InputWt}}{\partial Weight^2} = 2*\left(c + h*CN0_t + l*LC1250_{it}\right) \quad \text{(positive*)} \quad (9.a)$$

$$\frac{\partial^2 Basis^{750}_{InputWt}}{\partial Weight \cdot \partial CN0_t} = f + 2*h*Weight_{it} \quad \text{(positive)} \quad (9.b)$$

$$\frac{\partial^2 Basis^{750}_{InputWt}}{\partial Weight \cdot \partial LC1250_{it}} = g + 2*l*Weight_{it} \quad \text{(negative)} \quad (9.c)$$

Equations (8.a) – (8.c) and (9.a) – (9.c) are empirical counterparts to (5.a) – (5.c) and (6.a) – (6.c), respectively. These derivatives must be evaluated at specific values of the explanatory variables to determine their sign. The relationships are consistent with the comparative static results. First and second partials of basis with respect to weight depend on exogenous corn and live cattle prices and sale weight. The predicted sign of these derivatives also depends on the relative per pound price of gain and slaughter cattle. First partials and cross-partials with respect to both prices also exhibit consistency with the comparative static results in the sense that they depend only on weight. These maintain their predicted sign when sale weight is at or below the feeder cattle weight of 750 lbs.

The plots in figure 5 show predicted values of the dependent variable, $Basis^{750}_{InputWt}$, and the partial derivative relationships from Model 3. Predicted values are calculated at mean values of the live cattle and corn price variables and plotted against weight. These graphs make it visually apparent that the slope of the price slide (8.a) becomes more steep (negatively sloped) at lighter sale weights. An increase in the corn price produces a decrease in basis at all weights (8.b) and "flattens" the negative slope of the price slide to a greater degree at lighter weights (9.b). Similarly, live cattle price increases increase basis at all weights (8.c) and increase the "steepness" of the price slide to a greater degree for lighter cattle.

In order to more easily interpret and visualize the price slide dynamics, figures 6 and 7 plot predicted basis from Model 3 at different values of the corn an live cattle price. The price slide shown in the middle of both figures plots basis predictions at the sample mean values of both price variables (equivalent to figure 5). In figure 6, the corn price is held constant and two additional predictions are plotted for the live cattle price at one standard deviation above and below the sample mean of $78.33/cwt. Figure 7 holds live cattle price constant and plots predictions for corn prices one standard deviation above and below the mean value of $2.61/bushel. These figures clearly show the manner in which changes in live cattle and corn prices make the price slide steeper or flatter and have larger impacts on the price slide at lighter cattle weights.

Lot Characteristics

Several previous studies have demonstrated the importance of other lot characteristics in determining feeder cattle prices and basis. I control for and test the significance of several lot characteristics by adding them as additional explanatory variables in models 2 and 3. Table 5 displays estimates for the price and weight variables when other lot characteristics are included as Model 2(o) and Model 3(o). Coefficients for individual lot characteristics are suppressed. A comparison of estimated parameters from models with and without lot characteristics is informative. Most notably, the inclusion of lot characteristics produces a considerable improvement in the adjusted R-square for both models, suggesting that these factors are indeed important basis determinants. Further, the inclusion of lot characteristics does not cause appreciable change in the values of any of the price-weight coefficients.

Coefficients for the individual lot characteristic variables from the Model 3(o) specification are displayed separately in table 6. All of these estimates exhibit strong statistical significance, which is not surprising in light of the large number of observations. The sign of the coefficient on lot size is consistent with many previous studies (for example Dhuyvetter and Schroeder, 2000), which have shown that larger groups of cattle sell at a premium compared to smaller lots. Dummy variables were included for four additional characteristics: sex, class, month, and location. The estimates suggest that buyers pay a premium for steers relative to heifers or bulls and for cattle grading at class 1. Monthly dummy variables capture seasonal price differences and show that basis is lowest for feeder cattle that are sold in the fall months. This is consistent with previous research and also consistent with the notion that a large supply of spring calves results in a large supply of fall stocker cattle. Location dummies reveal that basis also differs based on where the cattle are sold. This might result from geographic price differences as well as from differences in the type of cattle that are sold at different auction locations.

VI. Conclusions and Future Research

The research presented in this working draft has demonstrated that empirical relationships between price and weight are consistent with predictions derived from a simple two-input derived demand model. Dynamics of the cattle price slide are clearly linked to changing conditions in the markets for corn feed inputs and live cattle outputs. Further, these relationships depend on future expectations of prices for cattle at different sale weights. Information about expected future market conditions for specific groups of cattle was incorporated by identifying appropriate futures contract prices.

The preliminary empirical analysis presented here suggests many possible areas for future exploration. For example, several explanatory variables could potentially be added to the model. These might include proxies for pasture feed inputs (ex., Palmer drought index), cattle inventory numbers, fuel costs, and recent feedlot profit margins. I also plan to consider the potential for additional dynamic interactions between the price slide and market or lot characteristics. Future empirical analysis will include more extensive treatment of contemporaneous corn and live cattle price relationships. In particular, I will explore whether high corn prices in recent years may have caused the price slide relationship to invert at certain points in time.

Most obviously, the analysis will be expanded to include a vast AMS database of feeder cattle transactions. This introduces regional variation in price slide dynamics that might stem from proximity to corn production and feedlot facilities or from regional differences in production practices and types of animals sold. Expanding the dataset will also introduce additional intertemporal variation by the inclusion of recent years with high and variable prices. I will look to exploit this substantial variation and contribute to the understanding of price slide dynamics.

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Table 1. Example feed cost calculations for two weights of the steer input

	Feeder	Stocker	
Output (slaughter) weight	1250	1250	lbs
- Input Weight	**750**	**550**	lbs
Gain Required	500	700	lbs
x Corn Conversion	*7*	*7*	
Corn Input (lbs)	3,500	4,900	lbs
÷ corn bushels / lb	*56*	*56*	
Corn Input (bushels)	62.5	87.5	bushels
x Corn Price ($/bushel)	$ 7.50	$ 7.50	per bushel
Gross Feeding Margin (GFM)	**$ 468.75**	**$ 656.25**	**per head**
Cost of Gain (COG)	**$ 0.94**	**$ 0.94**	**per lb**

Table 2. Example derived steer input values and prices

Price_LC1250	$ 1.24	$ 1.24	per lb
x Weight_1250	1250	1250	lbs
Slaughter value	$ 1,550.00	$ 1,550.00	$/hd
- GFM	$ 468.75	$ 656.25	$/hd
Steer Input Value (derived)	$ 1,081.25	$ 893.75	$/hd
÷ steer input weight	750	550	lbs
Steer Input Price (derived)	**$ 1.44**	**$ 1.63**	**per lb**

Table 3. Summary of example steer prices by weight

Steer type	Weight	Price	Value
Slaughter	1250	$ 1.24	$ 1,550.00
Feeder	750	$ 1.44	$ 1,081.25
Stocker	550	$ 1.63	$ 893.75

Table 4. Summary statistics for Kansas sample data

Number of observations = 282,152

Variable	Description	Units	Mean	Std Dev	Minimum	Maximum
SaleDate	YYYYMMDD		20031370.7	29550.4	19990106	20090326
Year	YYYY		2003	2.9566456	1999	2009
Weight	Sale weight	pounds	648.1	141.2	300	900
Price Variables						
$Basis^{750}_{it}$	[Cash price] - [FC750]	$/cwt	2.48	10.42	-63.62	87.33
Cash Price	Cash sale price	$/cwt	95.17	16.30	34.75	199.00
FC750	Price on sale date for feeder cattle futures contract that will be nearby when cattle weigh 750 lbs	$/cwt	92.32	12.52	69.97	119.57
CN0	Price on sale date for nearby corn futures contract price	$/bushel	2.61	0.91	1.75	7.61
LC1250	Price on sale date for live cattle contract that will be nearby when cattle weigh 1250 lbs	$/cwt	78.33	10.37	60.67	117.70
Interaction/Quadratic Terms						
Wt2			439982.46	178863.47	90000	810000
CN0*Wt			1697.02	732.742102	525.75003	6810.95
LC1250Wt			50843.18	13373.13	19740	100598
CN0*Wt2			1156605.42	664827.73	157725.01	6095800.33
LC1250Wt2			34561057.4	15142460.1	5922000.3	90336666.8
Lot Characteristics						
Lot Size	# head sold		25.0325959	64.7853519	1	3600
Str	Steers		0.5334784	0.4988788	0	1
Hfr	Heifers		0.463587	0.4986732	0	1
Bul	Bulls		0.0029346	0.0540924	0	1
Class1	Class 1		0.6654108	0.4718475	0	1
Class12	Class 1-2		0.1944413	0.3957707	0	1
Class2	Class 2		0.1357035	0.342474	0	1
Mo1	January		0.1168555	0.3212485	0	1
Mo2	February		0.0929889	0.2904174	0	1
Mo3	March		0.1228026	0.3282111	0	1
Mo4	April		0.1015233	0.3020209	0	1
Mo5	May		0.0651351	0.2467645	0	1
Mo6	June		0.0254225	0.1574047	0	1
Mo7	July		0.0492749	0.2164417	0	1
Mo8	August		0.0757393	0.264581	0	1
Mo9	September		0.0703734	0.2557757	0	1
Mo10	October		0.1130136	0.3166099	0	1
Mo11	November		0.1056452	0.3073835	0	1
Mo12	December		0.0612259	0.2397446	0	1
Loc01	Syracuse, KS		0.0378413	0.1908127	0	1
Loc02	Junction City, KS		0.0776993	0.2676982	0	1
Loc03	Winter Livestock Video		0.0017508	0.0418063	0	1
Loc04	Winter Livestock Auction		0.1928039	0.3945011	0	1
Loc05	Pratt Livestock Auction		0.265917	0.441821	0	1
Loc06	Kansas Direct Feeder Cattle		0.0553957	0.2287513	0	1
Loc07	Farmers & Ranchers Lvstk Co		0.3685921	0.4824239	0	1

Table 5. Model parameter estimates for price-weight variables

Dependent Variable = **$Basis^{750}_{it}$**

Number of observations = 282,152

Parameter	Model 1	Model 2	Model 2(o)	Model 3	Model 3(o)
Adj. R-square	***0.4834***	***0.4887***	***0.7438***	***0.5096***	***0.7581***
a Intercept	**66.83442**	**64.01814**	**54.13294**	**-94.74554**	**-82.56878**
	(0.25949)	(0.28440)	(0.21004)	(2.32976)	(1.64035)
	257.56	*225.10*	*257.73*	*-40.67*	*-50.34*
b Weight	**-0.15744**	**-0.15813**	**-0.12886**	**0.2677**	**0.24727**
	(0.00084697)	(0.00084271)	(0.00060393)	(0.00747)	(0.00526)
	-185.89	*-187.64*	*-213.37*	*35.84*	*47.01*
c Wt2	**0.000085666**	**0.00008634**	**0.00005586**	**-0.00018488**	**-0.0001905**
	(6.686718E-07)	(6.653638E-07)	(4.789582E-07)	(0.00000580)	(0.00000408)
	128.11	*129.76*	*116.63*	*-31.88*	*-46.69*
d CN0		**-1.27259**	**-2.23911**	**-27.73627**	**-25.64551**
		(0.2355)	(0.01743)	(0.45203)	(0.31815)
		-5.40	*-128.46*	*-61.36*	*-80.61*
e LC1250		**0.08021**	**0.19665**	**2.99828**	**2.73032**
		(0.00206)	(0.00158)	(0.04014)	(0.02827)
		38.94	*124.46*	*74.70*	*96.58*
f CN*Wt				**0.07012**	**0.06225**
				(0.00144)	(0.00101)
				48.69	*61.63*
g LC1250*Wt				**-0.0078**	**-0.0069**
				(0.00012775)	(0.00008997)
				-61.06	*-76.69*
h CNWt2				**-0.00004417**	**-0.00003922**
				(0.00000111)	(7.813848E-07)
				-39.79	*-50.19*
l LC1250Wt2				**0.00000495**	**0.00000447**
				(9.863877E-08)	(6.943237E-08)
				50.18	*64.38*
Lot Characteristics			**Included**		**Included**

Notes: Estimated **coefficients** (standard errors) and *t-statistics* are shown. All estimates are statistically significant with P-values <0.0001. Individual parameter estimates for lot characteristics included in models 2(o) and 3(o) have been suppressed.

Table 6. Individual parameter estimates for lot characteristics - Model 3(o)

Dependent Variable = $\textbf{Basis}^{750}_{it}$

Number of observations = 282,152

Parameter	Estimate	(StdErr)	*T-stat*
# Head Sold (Lot Size)	0.00169	(0.00017732)	*9.53*
Sex Dummies			
Steer	0		
Heifer	-8.14089	(0.01982)	*-410.74*
Bull	-6.88621	(0.17916)	*-38.44*
Class Dummies			
Class1	0		
Class12	-4.18968	(0.02570)	*-163.02*
Class2	-7.0359	(0.02988)	*-235.47*
Month Dummies			
January	4.00651	(0.04096)	*97.82*
February	5.37661	(0.04361)	*123.29*
March	5.7799	(0.04084)	*141.53*
April	6.73215	(0.04242)	*158.70*
May	5.35235	(0.04830)	*110.81*
June	4.13316	(0.06803)	*60.75*
July	4.48984	(0.05262)	*85.33*
August	3.76185	(0.04575)	*82.23*
September	2.22642	(0.04654)	*47.84*
October	0		
November	0.8747	(0.04143)	*21.11*
December	3.0218	(0.04861)	*62.16*
Location Dummies			
Syracuse, KS	-2.27804	(0.05340)	*-42.66*
Junction City, KS	-0.85572	(0.03909)	*-21.89*
Winter Livestock Video	-3.87664	(0.23314)	*-16.63*
Winter Livestock Auction	-1.32923	(0.02758)	*-48.20*
Pratt Livestock Auction	-0.66062	(0.02537)	*-26.04*
Kansas Direct Feeder Cattle	-1.61017	(0.05248)	*-30.68*
Farmers & Ranchers Lvstk Co	0		

Notes: Estimated **coefficients** (standard errors) and *t-statistics* are shown. All estimates are statistically significant with P-values <0.0001. Price and weight coefficients shown on table 5.

Figure 1. Example value, price, and feed cost calculations by steer input weight

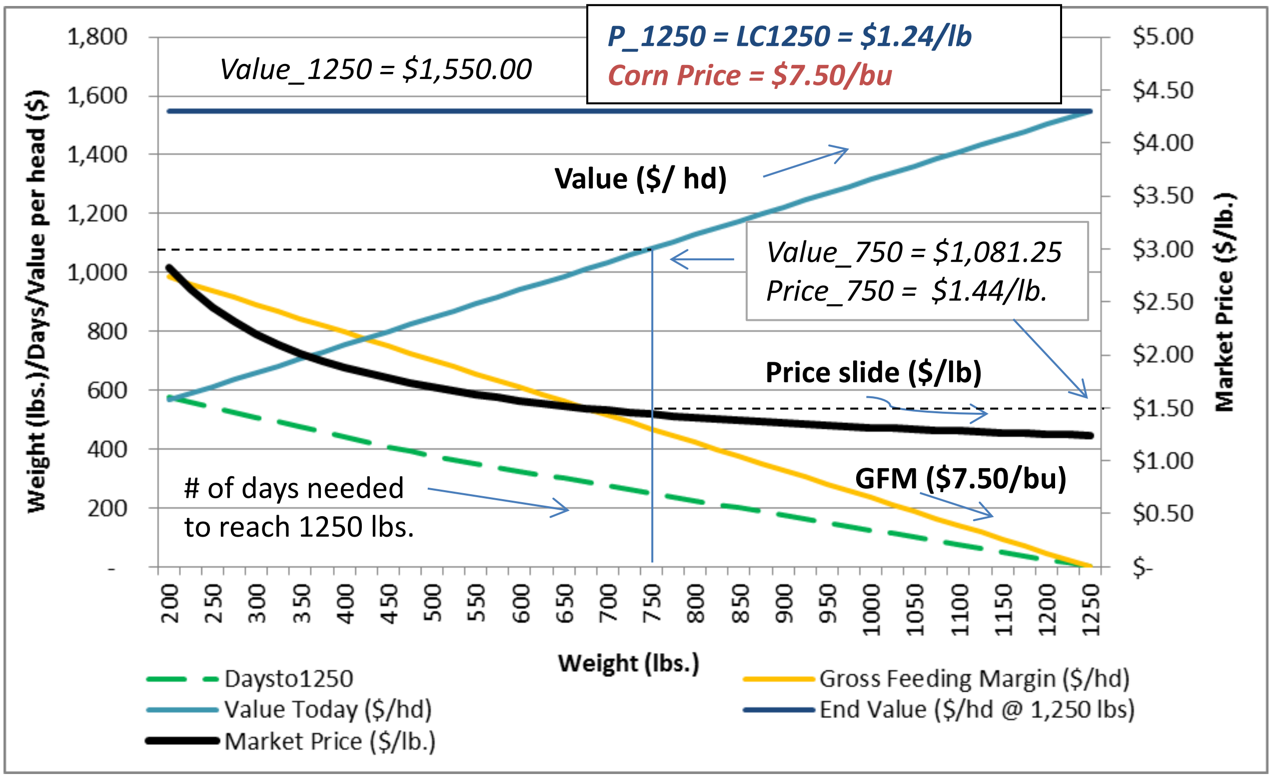

Figure 2. Example calculations with reduced corn price

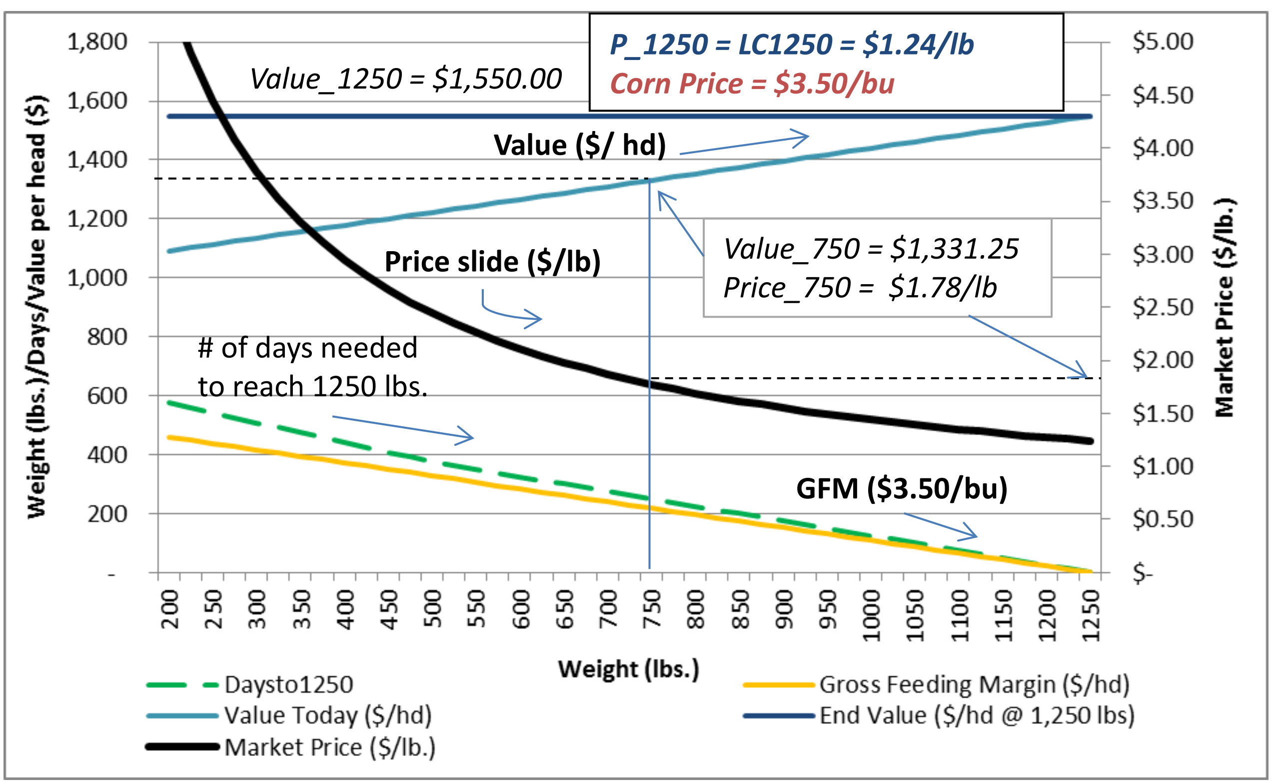

Figure 3. Example Derived Demand Market for Input Steers at 550 and 750 lb. Sale Weights

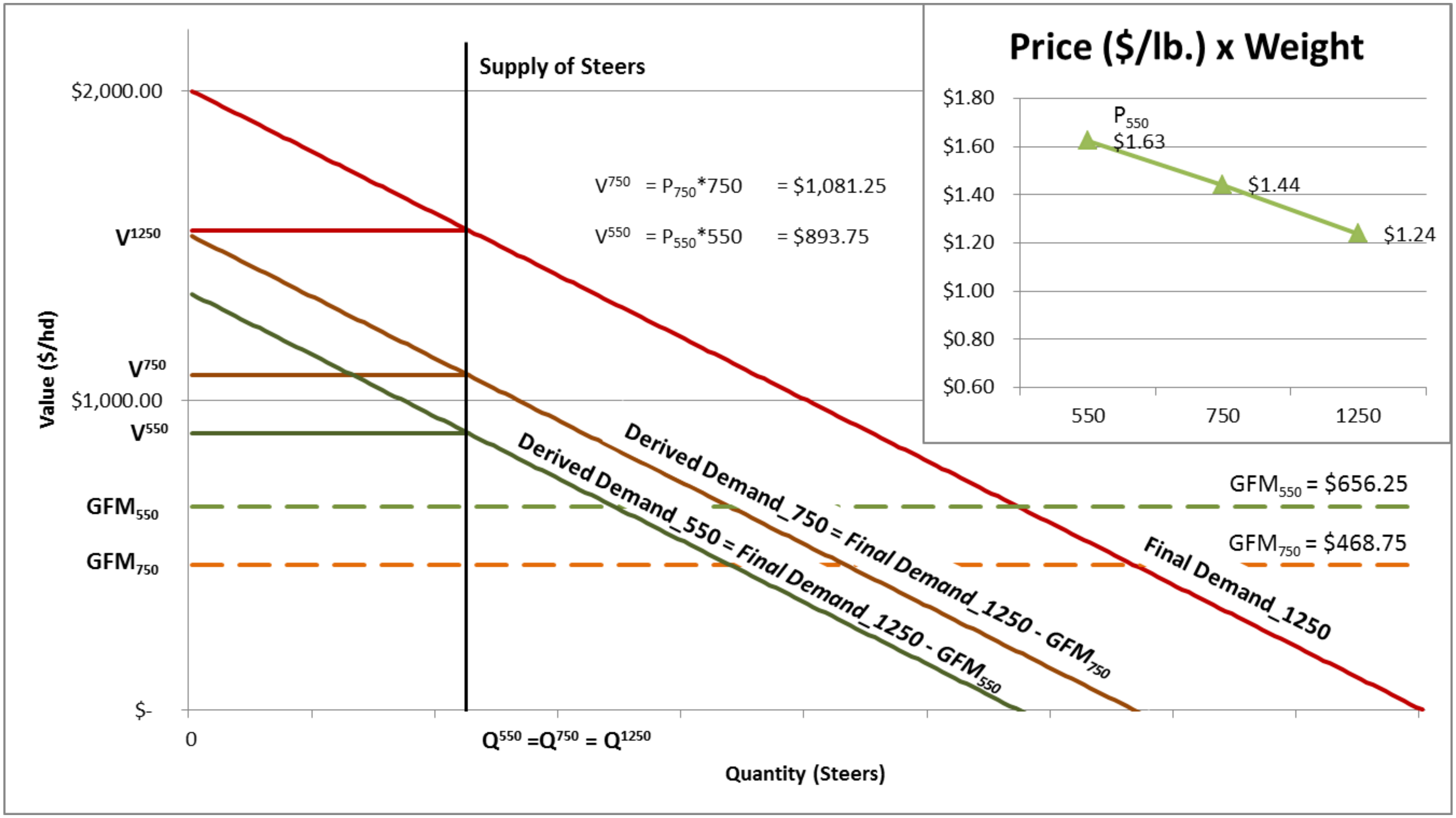

Figure 4. Example Derived Demand for Stocker and Feeder Steers with Different Quantities of Future Supply

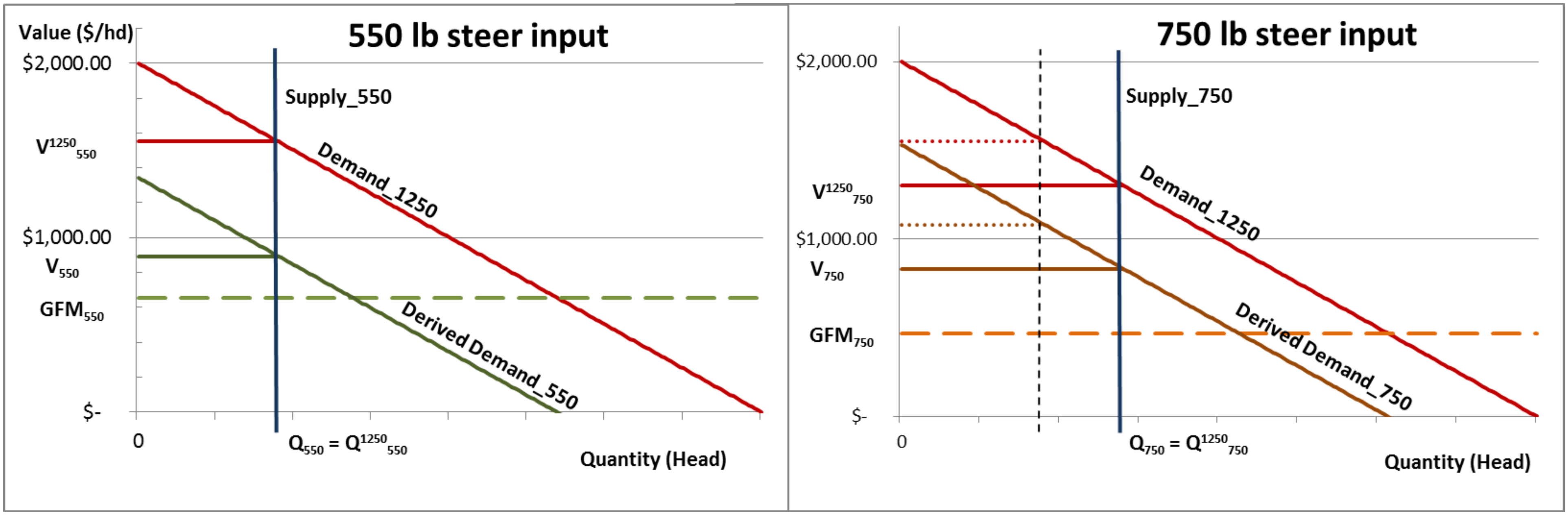

Figure 5. Model Predicted Basis and Partial Derivative Values by Weight

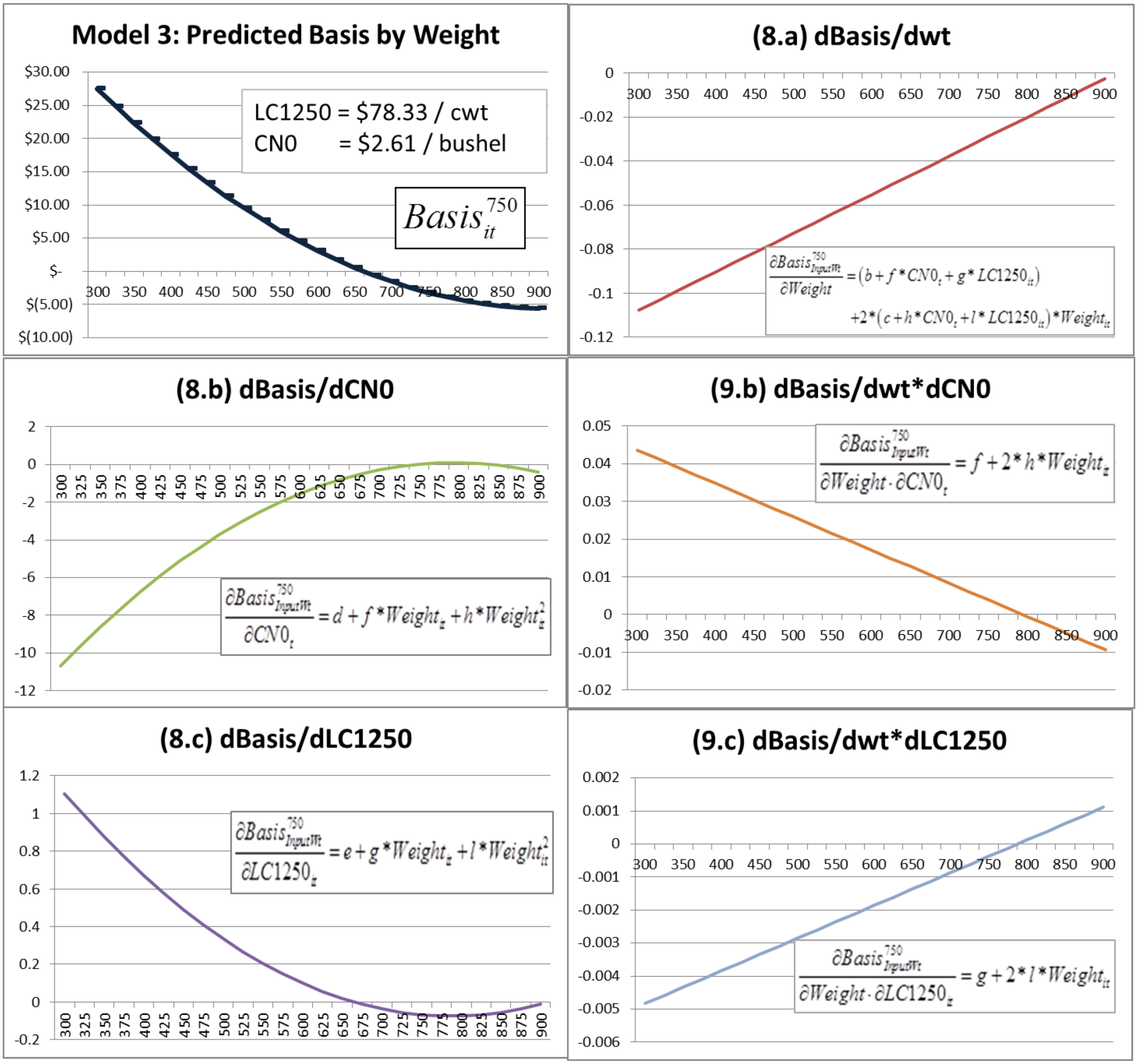

Figure 6. Model 3 Basis Predictions Showing Effects of a Change in Live Cattle Price

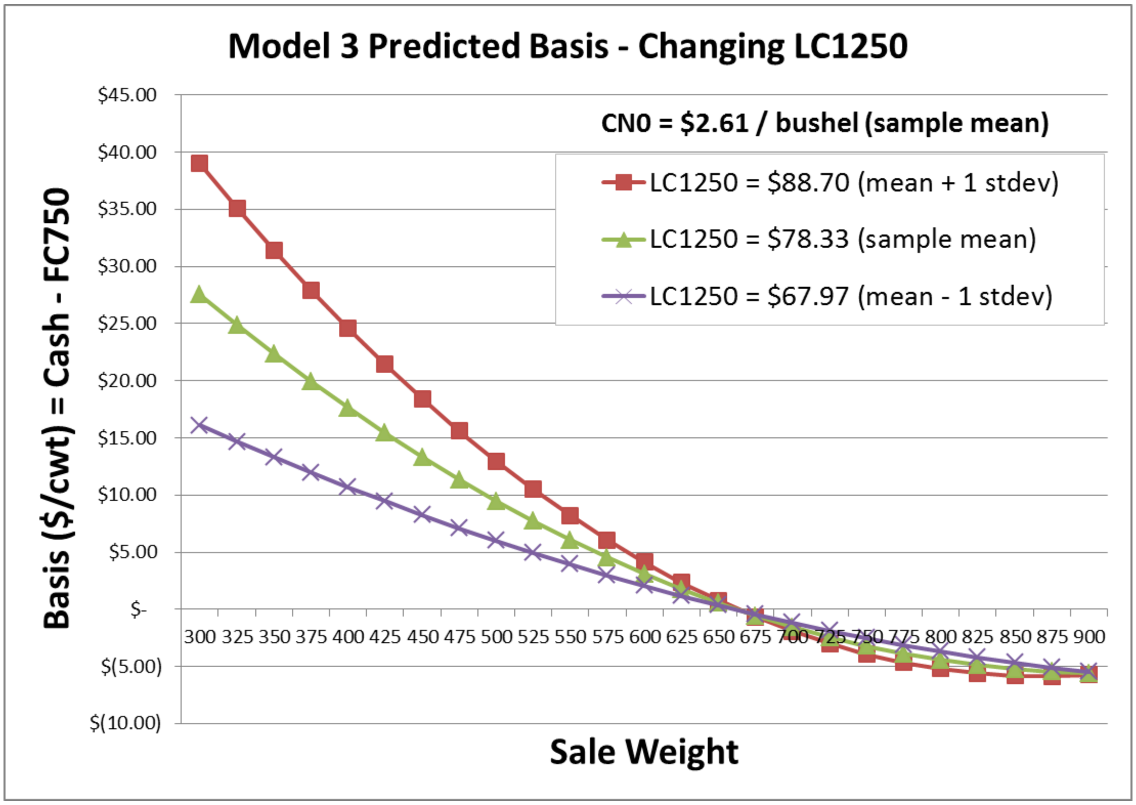

Figure 7. Model 3 Basis Predictions Showing Effects of a Change in Corn Price