Does the Law of One Price Hold for Feeder Cattle Purchased in Various Regions of the US and Shipped to One State in the Midwest?

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Feeder cattle prices vary considerably across various regions of the US. They also vary from state to state within a region and even from auction to auction within a state. Often times these regional, state, or even auctions specific price differences are expressed in terms of the deviation from the Chicago Mercantile Exchange Feeder Cattle Futures. This difference is commonly referred to as the basis. Research by Tonsor, Dhuyvetter and Mintert, 2004 looked at how reliable basis forecasts are in predicting local prices based on feeder cattle futures prices. Even within a narrow 50 pound weight range, prices may vary by more than $10 per cwt for steers sold on the same day at one specific auction. Prior research (Buccola 1980, Faminow and Gum 1986, Schroeder et al. 1988, Turner et al. 1991, and Feuz et al. 2008) has documented using hedonic regression analysis that feeder animal characteristics such as gender, weight, breed, frame size, flesh condition, size and consistency of sale lots and other management treatments and sale conditions do impact price and explains much of the variability of price within a specific region of the country. Recent work by Dhuyvetter, et al., 2008 combined the idea of basis forecasts with the hedonic regression analysis to not only make site specific basis forecasts, but also lot specific forecasts.

This prior research has sought to explain or predict prices at specific locations. However, little emphasis has been placed on examining differences across locations. The economic law of one price, which assumes that prices in different markets do not differ by more than transportation costs, is generally recognized to apply to agricultural commodity markets (Tomek and Robinson, 1990). This concept of the law of one price should apply to the feeder cattle market. If there were differences in the price, after adjusting for transportation, it would be assumed that there would be opportunity for arbitrage. The law of one price also assumes the commodities are homogeneous, or perhaps in the context of this paper that sale lots are homogeneous. However, the prior research on using hedonic regression analysis to explain differences in feeder cattle prices is an indication that feeder cattle sale lots are not homogenous.

Feeder cattle are produced in nearly all regions of the US. Many are eventually shipped to one of four major cattle feeding areas identified by Bailey, Brorsen, and Thomsen (1995). The first is the Omaha, Nebraska area which includes eastern Nebraska, eastern South Dakota, Iowa, and southern Minnesota. The second is the Greeley, Colorado area which contains feedlots in northeast Colorado and western Nebraska. Dodge City is the third area which includes feedlots in and around western Kansas. Lastly, the Amarillo, Texas feeding area which includes the Texas and Oklahoma panhandles. Are the prices paid for feeder cattle in different regions but destined to one of these feeding areas, for example Dodge City, equal once transportation costs and lot quality differences are considered?

The specific objective of this paper is to determine if the prices paid for feeder cattle from different regions of the US but destined for Kansas are equivalent, once those prices have been adjusted for transportation and quality differences between sale lots. In other words, we want to test the hypothesis that the law of one price holds for feeder cattle destined for the Dodge City, Kansas feedlot area.

Data and Methods

Auction Data was obtained from Superior Livestock Auction, a large national satellite video auction firm, for sales during 2004-2006. The data includes variables such as price, breed, sex, weight, origin, destination, number of head etc. The original data set contained over 30,000 lots of calf, yearling, and breeding stock. This paper has reduced the lots of cattle by only including feeder steers between 500-900 lbs that were destined for Kansas, and were marketed for delivery in the months of October and November. The data was narrowed to 831 sale lots.

In most of the prior studies on the value of particular feeder cattle characteristics the actual market price for each lot of cattle is the dependant variable. However, in this research basis is used as the dependant variable. Basis is defined as:

(1) $$BASIS_i = PRICE_i - FUTURES_j$$

Where PRICE is the actual price bid for the lot of cattle, and FUTURES is the value of the Chicago mercantile exchange (CME) feeder cattle contract on the auction date for the month of delivery. For Example, in order to obtain the correct futures data for a sale on the 10th of July with 100 days to delivery, the futures price used would be the CME October Feeder Cattle Future contract price on July 10th. Basis was used rather than the actual price because if one accepts the assumption that the futures markets are efficient and unbiased predictors of prices in the future, then buyers and sellers in the markets should be using the futures market to establish prices for feeder cattle for future delivery. Basis will be less impacted by changes in the market price level from one sale date to the next for the same expected delivery date than will the actual prices.

The Following equation was used to find the total transportation cost per hundred weight:

(2) TRANSPORTATION COSTS =

(RATE*MILEAGE/500)+((MILEAGE/100)*(WEIGHT*.61%)*(PRICE/100))/

(WEIGHT/100)- SHRINK

The TRANSPORTATION COSTS are based on truck weight capacity of 50,000 pounds and are shown in dollars per hundred weight; RATE is the annual average rate charged for trucking; MILEAGE is the estimated travel distance from origin of sale to the sale destination; 0.61% is a constant percent shrink of body weight for each 100 miles in shipment (Brownson, 1996);WEIGHT is the actual weight of the animal; PRICE is the actual price agreed upon during the auction; SHRINK is the pencil shrink agreed upon as terms of the sale. Average freight rates for the years 2004, 2005, and 2006 were $2.45, $2.67, and $3.30 per mile (Feuz et al. 2008).

The transportation cost per cwt for each sale lot was added to the basis to achieve a transportation adjusted basis. This basis would represent the expected basis if transportation were free. In other words, if buyers were not paying any actual freight, were not expecting the cattle to lose weight, and were not receiving any pencil shrink, then this would be the price that should have been offered if buyers and sellers were correctly accounting for transportation in their negotiations.

Once basis has been adjusted for transportation costs, basis must also be adjusted to reflect difference in lot size and quality. Lancastrian demand theory suggests that the value of a particular good is the sum of the value of the individual characteristics that make up that good. This holds true in the feeder cattle market. Buyers are buying attributes such as breed, weight, origin and destination, number of head, and days to delivery. These characteristics make up the price that is paid for a lot of cattle and therefore determine the basis for that particular lot.

The general form of the equation to obtain the value of individual lot characteristics can be written as:

(3) $$b_i = \alpha_0 + \sum_{j=1}^{J} \beta_j CC_{ij} + \sum_{k=1}^{K} \gamma_k LC_{ik} + \sum_{n=1}^{N} \theta_n MC_{in} + \varepsilon_i$$

where b_i is the basis for the i^{th} lot for i = 1,2,3,…,I, where I is the number of lots sold in the dataset. The intercept is represented as α_0 with ε_i as white noise error term. CC is the j^{th} cattle characteristic of the i^{th} lot of cattle, LC is the k^{th} lot characteristics of the i^{th} lot of cattle, and MC is the n^{th} market characteristic for the i^{th} lot of cattle with β_j, γ_k and θ_n are parameter estimates. This equation is similar to that used by Bailey, Brorsen, and Fawson (1993). Equation 3 was estimated using ordinary least squares regression. The model was found to have problems of heteroscedasticity. Consequently, a White estimator was used to correct for heteroscedasticity and provide more accurate results.

The cattle, lot, and market characteristic variables used in the analysis are displayed in Table 1. Basis is the dependent variable and is in dollars per hundred weight. The majority of previous literature has shown that breed impacts cattle prices (Bailey and Peterson, 1991; Brazle, et al., 1988; Faminow and Gum, 1986; Schroeder, et al., 1998; Smith, et al., 2000; Turner, Dykes , and McKissick, 1991; Ward and Lalman, 2003). The base breed for the hedonic regression analysis is ANGUS. Other breed combinations are as follows: ANGENG, Angus-English Cross; ANENEX, Angus-English-Exotic Cross; ANGEXOT, Angus-Exotic Cross; ENEXER, English-Exotic-Ear; CHARANG, Charolais-Angus Cross; REDANG, Red angus; and OTHER, all other breeds and cross breeds. All breeds and breed combinations compared to ANGUS are expected to have a negative impact on basis. Research has indicated buyer preference for larger framed and lighter fleshed feeder cattle (Bailey and Peterson, 1991; Brazle, et al., 1988; Schroeder, et al., 1998; Smith, et al., 2000; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). LRGFRAME (large frame) is expected to have a positive impact, and SMLFRAME (small frame) is expected to have a negative impact on basis in comparison to medium frame cattle. HVFLESH (heavy flesh) is expected to have a negative impact, and LTFLESH (light flesh) is expected to have a positive impact on basis in comparison to medium flesh cattle. EVEN (cattle that are uniform) is expected to have a positive impact on basis. The presence of HORNS is expected to have a negative effect on basis, which would be consistent with prior research (Bailey and Peterson, 1991; Brazle, et al., 1988; Schroeder, et at., 1998; Ward and Lalman, 2003). IMPLANT (steroid implants) are expected to have a negative coefficient. Turner, Dykes, and McKissick (1991) found that as "pencil shrink" offered increased the price received also increased. SHRINK is expected to have a positive affect on basis. FUTURES (Futures Price) may also impact the price offered for feeder cattle. If higher price level, as reflected by the futures market, lead to even higher cash prices, then the impact on basis may be positive. If higher overall price levels create an uncertainty, and the cash market does not follow the futures, then the impact on basis may be negative. The sign is left undecided at this time.

The primary purpose in conducting the hedonic analysis is to be able to adjust basis based on lot quality differences. Therefore once the hedonic model was estimated the coefficients were used to adjust all lots to a standardized lot. The data was classified into four weight categories: 500-599 lbs, 600-699lbs, 700-799lbs, and 800-899lbs and each lots basis was adjusted to reflect the midpoint of the weight range ie., 550, 650, 750 and 850, respectively. For each weight category the lot size was adjusted to reflect one 50,000 lb tuck load lot. Premium received for the actual lot were deducted and discounts were added to arrive at a standard lot of Angus, medium frame, medium fleshed, no horns, non-implanted cattle. We then arrive at a predicted transportation and quality adjusted basis for each sale lot.

The United States was divided into seven regions (Table 2) and each sale lot was placed in a region based on the origin of the cattle. The West and Northeast regions were removed from the analysis because of to few observations. The PROC GLM in SAS was used to determine if the mean values for the transportation and quality adjusted basis by region were statistically equal for each weight category. The hypothesis of this project is that after basis has been adjusted for quality differences and transportation costs, there will be no difference of basis levels between regions. This would imply that the law of one price is in existence in the feeder cattle market.

Results

The regression was estimated using ordinary least squares with a White Estimator to adjust for heteroscedasticity. This regression was used to determine the impact of various attributes cattle, lot, and market characteristics had on BASIS for the sale lots. The model has an R-squared of 77 percent. Therefore the model accounted for 77 percent of the variation in basis. Each one of the coefficients explains how much basis would change with a one unit change in the independent variable. Angus was used as the default breed and as projected, all other breeds and breed combination were discounted and decreased basis. The estimates for flesh were as expected. HVFLESH cattle had a negative coefficient and the LTFLESH cattle had a positive coefficient. The LTFLESH coefficient did not have enough observations to be statistically significant, but the sign was as expected. LRGFRAME cattle had a positive parameter as expected while SMLFRAME cattle had a negative parameter. The SMLFRAME variable was also statistically insignificant because there were not sufficient observations within the SMLFRAME category. Cattle that were uniform and grouped nicely were given a premium for being an EVEN lot. Cattle lots that had HORNS were discounted $1.82/cwt. It is important to note that scurs and nubs were included as horns. IMPLANTS were statistically insignificant. SHRINK had a positive effect on basis as was expected. FUTURES was significant and had a negative impact on BASIS. The number of HEAD sold was positive and was nonlinear as expected. Kansas was used as the default region and all of the other regions had a negative effect on basis. The Midwest had a negative coefficient, but is statistically insignificant. This is probably because Kansas is located in the Midwest and there was no real difference between prices. MILEAGE had a negative effect on basis. The farther away from the destination the smaller the basis. WEIGHT, WEIGHT^2, and WEIGHT^3 were all significant and yielded the expected results. The basis price slide is impacted by expected costs of gains in feedlots. This reflects the cost of feed during 2004-2006. The quality adjusted basis used the measures of this hedonic analysis to make the quality adjustments. Not all the parameters were used in analysis. Mileage and Shrink were left out because they were already accounted for in the transportation costs. The region differentials were removed because the means were measured by region.

There was significant variation in basis from region to region before any transportation or quality adjustments were made, Table 4. This suggests that prices are different across regions before transportation and quality is accounted for. The variation in mean basis across regions was $5-10 per cwt. depending upon the weight category and represents a difference in value of $40-50 per head. This difference is not only statistical significant but is economically significant as well.

Transportation costs per hundred weight were determined for each sale lot and added to the basis. Basis was then adjusted using the parameter estimates from the hedonic regression. The mean quality and transportation adjusted basis for each region and weight classification are displayed in Table 5. Analysis of the data would suggest that at the 800lb weight class that there is no real significant difference in basis across regions. The 700 weight class also shows no significant difference in basis across regions. In the 600 weight class there is some variation across regions. The southwest region has a lower basis than the rest of the regions. Sale lots in that region and weight category had a basis that was about $3.00-6.50 per cwt. lower than the other regions. In the 500 pound weight class the Southwest and Southeast regions received a lower basis than the other regions. Basis was about $1.50 to $4.50 per cwt. lower, depending upon the comparison, a difference of $8-24 per head.

Conclusions

The question to be answered by this research was to essentially determine if prices, which varied considerably from region to region in the US, were equivalent once they had been adjusted for transportation costs and lot quality differences. Auction Data obtained from Superior Livestock Auction for sales during 2004-2006 were used for the analysis. There were 831 sale lots of feeder steers between 500-900 lbs that were destined for Kansas, and were marketed for delivery in the months of October and November. Basis was determined for each sale lot.

Prior to making any adjustments, basis did differ significantly across regions of the country for all weight categories of feeder steers. Basis for each sale lot was adjusted to account for expected transportation costs, including freight costs, expected cattle shrink and adjustments were made for “pencil” shrink that was part of the transaction. Basis was also adjusted to a standard lot size, and breed and quality of cattle. Once these adjustments were made, basis was found to be statistically equivalent across regions for the 700-799 and 800-899 pound weight categories. Some statistically significant differences in basis by region remained for the lighter 500-599 and 600-699 pound weight categories.

Perhaps one explanation for the remaining differences at the lighter weights might be that not all of these feeder cattle may be destined for immediate placement into a feedlot. Some may be destined for wheat pastures or other stocker or background programs. The quality traits of economic significance in these programs may differ from those of a feedlot. Therefore, there could be more variability in the actual value of these cattle and this analysis may not have accounted for those differences in the quality adjustments that were made.

Based on the results of this research, it appears that heavy feeder cattle prices do follow the theory of the law of one price. While we found some basis differences at lighter weight feeder cattle categories, there could have been other market considerations that our model didn’t consider.

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Table 1. Descriptive Statistics

Variable	Mean	Maximum	Minimum	Std. Dev.
BASIS	11.863	41	-24	9.6800
ANGUS	0.231	1	0	0.0146
ANGENG	0.088	1	0	0.2830
ANENEX	0.083	1	0	0.2758
ANGEXOT	0.153	1	0	0.3607
ENEXER	0.145	1	0	0.3523
CHARANG	0.068	1	0	0.2523
REDANG	0.022	1	0	0.1465
OTHER	0.211	1	0	0.4081
HVFLESH	0.007	1	0	0.0852
LTFLESH	0.095	1	0	0.2934
LRGFRAME	0.127	1	0	0.3328
SMLFRAME	0.002	1	0	0.0493
EVEN	0.061	3	0	0.2541
HORNS	0.290	1	0	0.4540
IMPLANT	0.328	3	0	0.4774
SHRINK	1.717	3	0	0.8968
FUTURES	110.638	118	98	4.0274
HEAD	112.007	540	24	63.4958
IM	0.363	1	0	0.4812
MIDWEST	0.152	1	0	0.3595
SWEST	0.230	1	0	0.4212
SEAST	0.069	1	0	0.2543
MILEAGE	398.921	1327	0	263.5776
WEIGHT	616.267	885	500	86.6433
YR04	0.348	1	0	0.4767
YR05	0.297	1	0	0.4573

Table 2. Division of US states into five regions for the analysis

Region	States
Kansas	Kansas
Southeast	Florida, Georgia, Alabama Mississipi Louisiana, Arkansas, North Carolina, Tennessee, Kentucky
Southwest	Oklahoma, Texas, Arizona, New Mexico
Midwest	Nebraska, North Dakota, South Dakota, Minnesota, Iowa, Missouri
Intermountain	Idaho, Montana, Wyoming, Colorado, Nevada, Utah

Table 3. OLS-White parameter estimates for feeder cattle basis ($/cwt.) differentials

Variable	Coefficient	Standard Error	P-value
Adjusted R-squared	0.7663		
ANGENG	-2.0064	0.6531	0.002
ANENEX	-3.4158	0.6721	0.000
ANGEXOT	-3.1926	0.5203	0.000
ENEXER	-5.4998	0.6747	0.000
CHARANG	-3.0214	0.6871	0.000
REDANG	-1.7547	0.8519	0.040
OTHER	-4.5255	0.6268	0.000
HVFLESH	-5.1835	1.1347	0.000
LTFLESH	0.2730	0.6960	0.695
LRGFRAME	1.7404	0.5180	0.001
SMLFRAME	-8.9967	9.7646	0.357
EVEN	1.1800	0.5877	0.045
HORNS	-1.8213	0.4683	0.000
IMPLANT	0.6073	0.3303	0.066
SHRINK	0.5410	0.1957	0.006
FUTURES	-0.4182	0.0446	0.000
HEAD	0.0522	0.0216	0.016
HEAD^2	-0.0002	0.0001	0.040
HEAD^3	3.06E-07	0.0000	0.021
IM	-1.7856	0.7247	0.014
MIDWEST	-0.6381	0.8048	0.428
SWEST	-3.9439	0.6022	0.000
SEAST	-5.8934	1.0284	0.000
MILEAGE	-0.0041	0.0010	0.000
WEIGHT	-1.6590	0.2387	0.000
WEIGHT^2	0.0022	0.0004	0.000
WEIGHT^3	-1.01E-06	0.0000	0.000
YR04	1.5824	0.4453	0.000
YR05	2.1562	0.4158	0.000

Table 4. Difference of Mean Basis by Weight and Region.

Region	500-599	600-699	700-799	800-899
Kansas	19.88_{c}	12.55_{b}	2.27_{ab}	-0.911_{a}
Southeast	10.02_{a}	1.12_{a}	-2.39_{a}	-5.73_{a}
Southwest	15.99_{b}	4.91_{a}	3.13_{ab}	-4.71_{a}
Midwest	20.20_{c}	12.82_{b}	5.76_{b}	-4.86_{a}
IM	18.24_{bc}	10.28_{b}	4.73_{ab}	-2.65_{a}

Means with matching subscripts in each weight column signify that basis is statistically the same at the 99 percent level of confidence. The subscript "a" denotes the smallest mean and each successive letter is a statistically higher mean.

Table 5. Difference of Mean Quality and Transportation Adjusted Basis by Region

Region	500-599	600-699	700-799	800-899
Kansas	21.43_{b}	11.04_{b}	5.61_{a}	0.18_{a}
Southeast	20.12_{a}	12.08_{bc}	9.52_{a}	1.08_{a}
Southwest	18.59_{a}	8.01_{a}	6.80_{a}	-2.23_{a}
Midwest	22.73_{b}	14.65_{c}	6.61_{a}	0.86_{a}
IM	22.91_{b}	14.63_{c}	7.82_{a}	0.60_{a}

Means with matching subscripts in each weight column signify that basis is statistically the same at the 99 percent level of confidence. The subscript "a" denotes the smallest mean and each successive letter is a statistically higher mean.