AN EVALUATION OF DISTLLER'S GRAIN PRICE RELATIONSHIPS AND IMPLICATIONS OF INCREASED ETHANOL PRODUCTION ON GRAIN PROCESSING PRACTICES IN COMMERCIAL FEEDLOTS.

by

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Abstract

Very rapid growth in the ethanol industry has led to a void of information regarding price dynamics and utilization of distiller's grains. Understanding market conditions is essential for livestock producers to make informed decisions in the procurement of feedstuffs, especially as grain price levels have recently increased substantially. In this study, distiller's grain price discovery dynamics are evaluated to develop an understanding of spatial price relationships. The knowledge of price relationships reveals that users of distiller's grain should shop around when procuring the feedstuff. Additionally, because animal performance may be altered with increased inclusion of distiller's grains, regional competitive advantages could shift fed cattle production to geographic regions characterized by high of ethanol production plants. Therefore, the cost of current grain processing methods are evaluated to enhance the awareness of regional competitiveness and long term sustainability. The combination of these two objectives allows producers to better realize the implications of the ethanol industry on their ability to maintain their operations into the near future.

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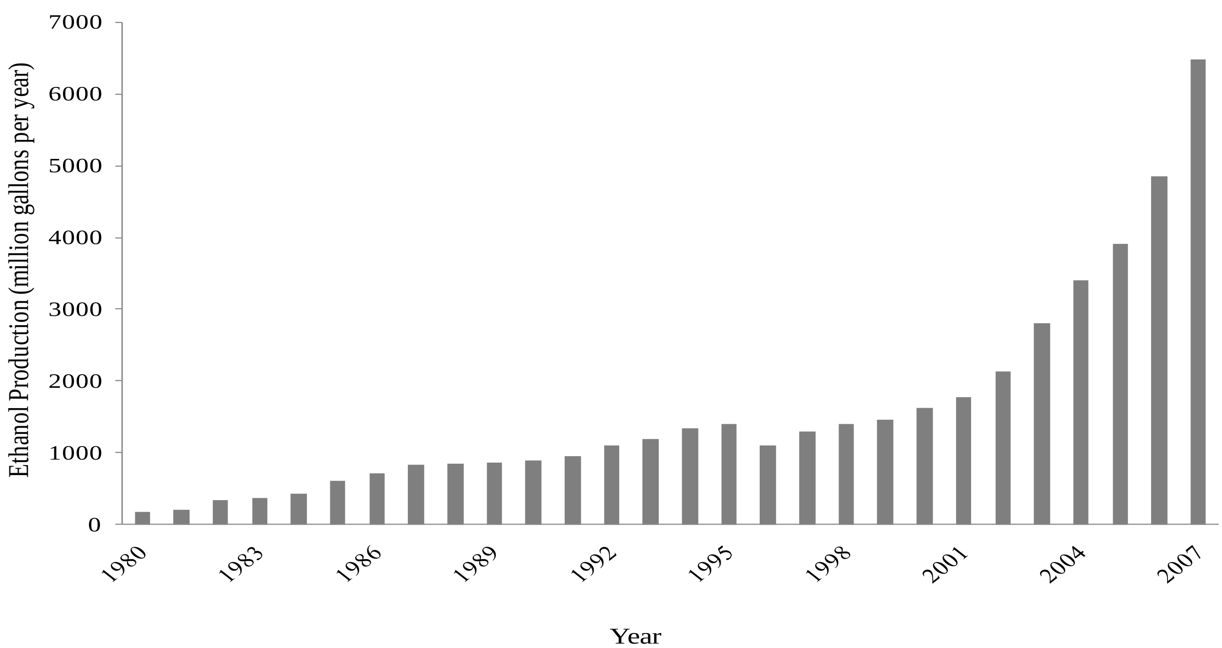
CHAPTER 1 - Introduction

The ethanol industry has experienced dramatic structural shifts and production potential in recent years in response to policy incentives. The production of domestic corn based ethanol has substantially increased in recent years, and furthermore has surpassed historical production levels each year since 2000, as demonstrated in Figure 1.1. Understandably, the majority of this growth has occurred in the heart of the Corn-Belt, where grains are more readily available. The growth in this region is exemplified by the fact that Iowa, Illinois, Nebraska, Minnesota, and South Dakota have been among the top five ethanol producing states since 2001, according to the Renewable Fuels Association (RFA). Additionally, in 2007 each of these states were in the top six in corn production based on National Agricultural Statistics Service (NASS) data. Moreover, the RFA points out that these five states encompassed 69.9% of the listed current ethanol production operating capacity as of December 2007.

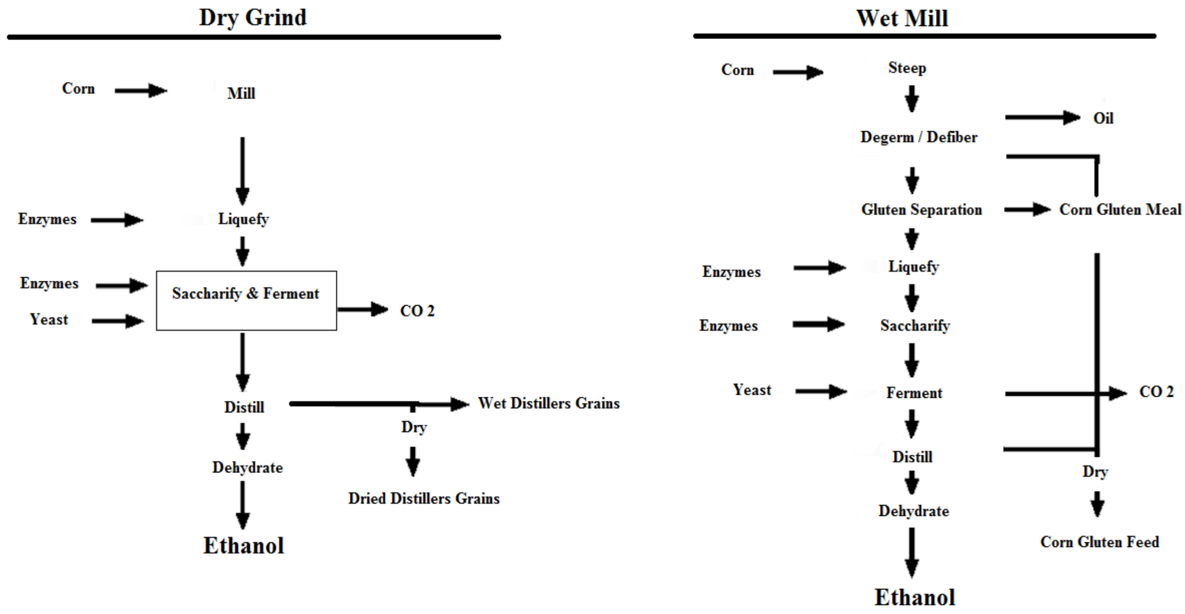
Figure 1.1 United States Annual Ethanol Production, 1980-2007.



Source: Renewable Fuels Association (2008)

Currently, ethanol is most commonly produced through the dry mill process, which has a lower initial investment cost and is more efficient compared to a “wet” mill (Shapouri, Gallagher, Graboski 1998). In both processes, an output is ethanol, although the procedures and by-products associated with two types of production are unique to the specific milling format (Figure 1.2). The dry milling process results in two by-products, dried distiller’s grain (DDG) and wet distillers grain WDG, which are simply distinguished by moisture content. While there is currently not a standard moisture requirement used to classify distiller’s grains (DG) as WDG or DDG, the industry generally reports DDG as having a moisture content of 10-15%, and WDG having a moisture content of approximately 65-70%. In 2001, the ethanol industry was evenly divided in terms of mill type, with about half employing the dry mill process and half using wet mills. However, the RFA states that by 2006, the industry had shifted to nearly an 80-20 split, with dry mills being the majority. The RFA 2008 Annual Outlook indicates that of the production from the dry mill process, 64% of DG production was dried to form the product DDG and 36% was kept as a wet product (WDG) in 2007. The growth of ethanol, and therefore DG production in the United States has grown from about 3 million metric tons in 2001 to nearly 15 million in 2007, and is expected to surpass 20 million tons by 2009 RFA (2007). Though both mills produce ethanol, there are key differences in products and characteristics when evaluating the by-product output for each type of mill.

Figure 1.2 Differences in Dry Grind and Wet Milling Ethanol Production Processes.



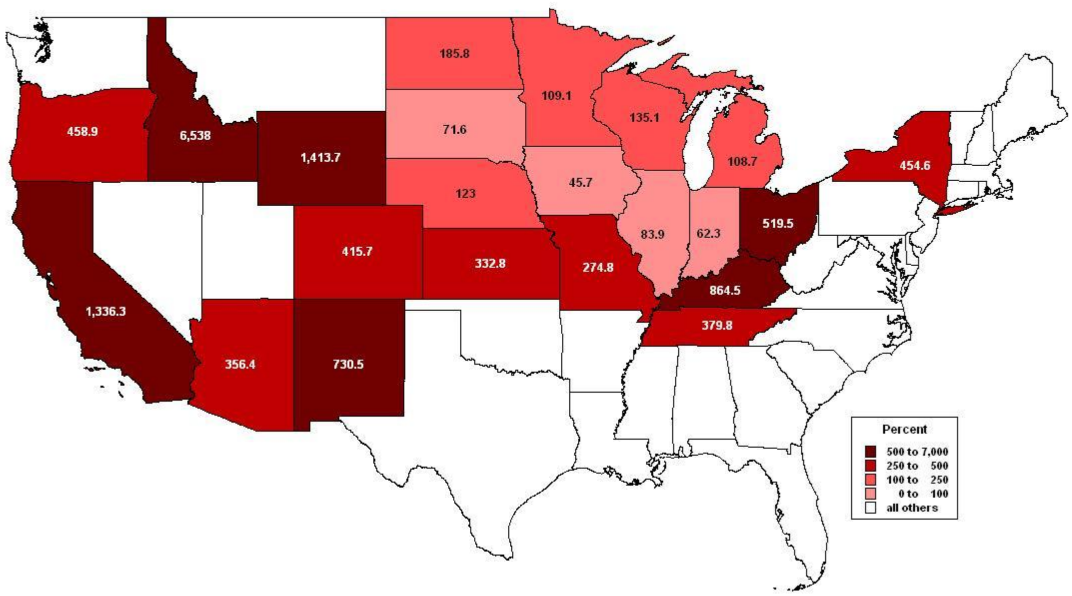
Reproduced from Bothast and Schlicher (2005)

Utilization of Ethanol By-Products by Livestock Producers

The very rapid growth in the ethanol industry has led to a void of information regarding the price dynamics and the utilization of DG. Understanding market conditions is essential for livestock producers to make informed decisions in the procurement of feedstuffs, especially as grain prices have increased substantially in recent years. Furthermore, the significance of potential spatial consumption, as well as transportation costs and issues[1] of DG, suggests that regional market dynamics are vital to the economics of both livestock producers and ethanol plants. To better illustrate the geographic characteristics of the market, Figure 1.3 presents the regions currently with DDG surplus and deficit. Though DG are transportable, results of Erickson et al. (2007) show that transporting WDG beyond 100 miles and dietary inclusion levels beyond 45 percent, on a dry matter (DM) basis, in beef diets lead to negative returns. This suggests that there are distance limitations when transporting WDG, signaling further that the geographic location of the buyer with respect to the ethanol plant is important. There do not appear to be similar restrictions when transporting DDG.

[1] Transportation distance is a significant issue for WDG due to the cost of transporting water.

Figure 1.3 Percent of Current DDG Production Potentially Consumed by All Livestock in Ethanol Producing States.



Sources: Dhuyvetter, Kastens, and Boland (2005), National Agricultural Statistics Service (2008), and Renewable Fuels Association (2008)

Coupling current ethanol production levels with increased grain prices, livestock producers are exploring potential substitutes for limited amounts of concentrate grains in feed rations. Logically, DG have been a common choice as they have become more readily available. Moreover, cattle feeders and dairies have been highlighted by the RFA as industries that have the most opportunity in the DG market. In 2007, beef cattle operations and dairies accounted for nearly 84% of all North American DG consumption. However, management strategies may need to be altered when incorporating DG due to price dynamics, product procurement, animal performance, and in the case of WDG, shelf life[2] of the product. Collectively, these issues are some of the most important factors to consider when evaluating potential production practices for livestock producers.

Cattle are the primary consumers of DG, but because cattle feeders' primary objective is to increase the weight of an animal and are more generally concentrated locations where high

[2] The composition of WDG makes it prone to mold, especially in warmer temperatures, therefore limiting useful shelf life to approximately 5-10 days.

levels of concentrate grain consumption occur, they are emphasized in this research. This does not discredit the significance of consumption by the dairy sector. The changes in efficiency of weight gain when DG are incorporated in rations, with respect to the type of grain processing (i.e., dry rolled or steam flaked grains), are important considerations when evaluating regional competitiveness. Cattle feeding operations in states in the upper Midwest, such as Nebraska, South Dakota, and Iowa, typically employ dry-rolling, while states such as Kansas and Texas more commonly utilize steam flaking systems for grain processing. Animal performance in regard inclusion levels of DG when added to diets using various grain types and processing methods vary, and therefore create potential new competitive regional advantages and possibly structural shifts in the industry. A recent survey by Vasconcelos and Galyean (2007) shows that of 29 nutritionists, 65% recommend steam flaking as the primary form of grain processing, while only about 14% suggest dry rolling. However, if the dry rolling grain processing method is superior in terms of animal performance when using DG, the industry could potentially relocate to states where DG are more abundant.

Research Objectives

The general objective of this research is to address the key elements for cattle feeders to consider when incorporating DG in rations. Particular objectives of this research are:

1. Determine spatial and temporal price relationships among DG markets, by evaluating cointegration, causality, and price risk management strategies.

2. Quantify the cost of steam flaking corn, and evaluate the driving factors of production costs. Also, benchmark indexing of a sample of industry firms, cross-sectional analysis provides information to evaluate the associated costs and efficiencies of steam flaking across feedlots.

3. Combine DG price dynamics, animal performance, and grain processing cost characteristics to evaluate critical production points where cattle feeders should seek alternative production methods.

To date, there has been very limited published research addressing the first objective. Therefore, the increased understanding of DG price relationships will provide important information of market dynamics to the market participants. The second objective, however, is preceded by literature which uses energy utilization and efficiency assumptions to calculate processing costs, and therefore the industry is in need of empirical analysis across firms to better understand the variability and realized costs when steam flaking corn. Lastly, by coupling animal performance estimates associated with increased DG inclusion with DG price dynamics and current grain processing costs, an assessment of regional cattle feeding cost advantages will enhance the understanding of sustainability and highlight critical points of production where alternative methods such as dry rolling should be considered.

The layout of the remaining paper includes three main sections. The first section is a standalone paper addressing DG price discovery and market dynamics. Following that paper is a second self-contained paper evaluating the cost of steam flaking corn, specifically examining the variability and contributing factors of the cost of steam flaking for commercial feedlots. The final portion of this work is the implications, portion which combines the results of the first two papers together to analyze regional sustainability as a result of corn based ethanol growth.

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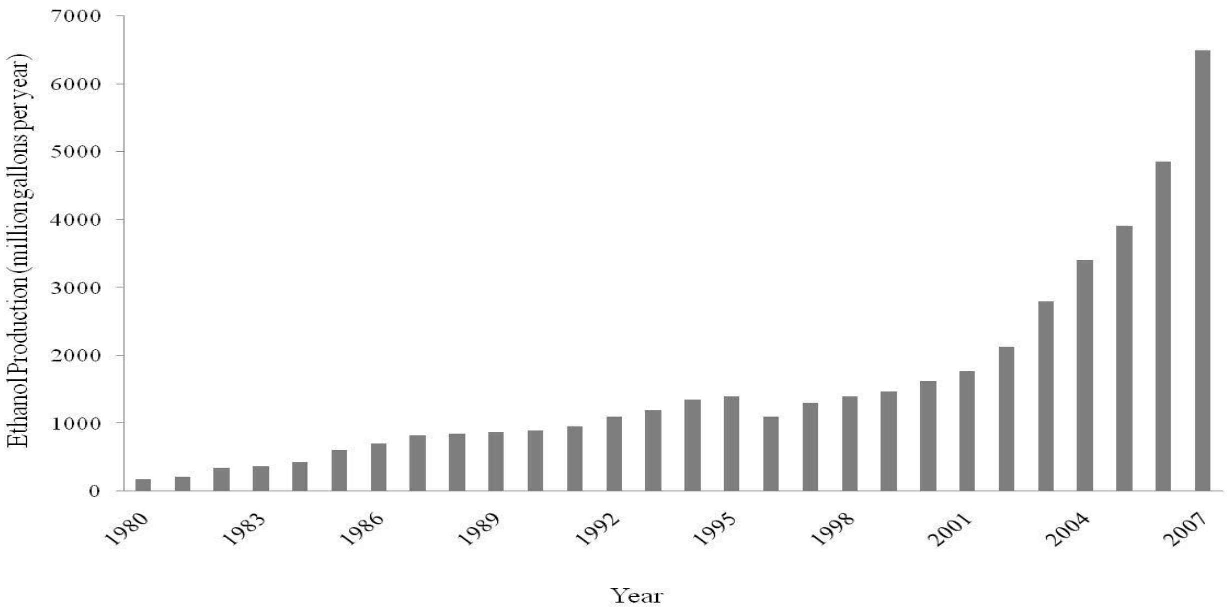
CHAPTER 2 - Spatial Price Discovery, Dynamics, and Leadership in Evolving Distiller's Grain Markets

Corn-based ethanol production has experienced record production each of the last seven years (Figure 2.1), resulting in a dramatic increase in distiller's grain production, a by-product of the corn refining process.[3] Strong demand for corn by the ethanol industry contributed to substantial corn and distiller's grain price volatility and encouraged record corn production in 2007. The substantial increase in corn usage by the ethanol refinery industry has resulted in livestock producers, especially dairies and cattle feeders, substituting distiller's grain for corn in feed rations. Distiller's grain markets are in development, no publicly traded cash or futures market exchange exists, and publicly available market information about distiller's grain is sparse. With the growing importance of distiller's grain markets, information is needed regarding spatial and temporal price relationships in the industry to assess market efficiency and to determine whether existing futures markets provide price risk management opportunities for distiller's grain market participants.

[3] One 56-pound bushel of corn results in approximately 2.8 gallons of ethanol and 17 pounds of dried distiller's grain.

Figure 2.1 United States Annual Ethanol Production, 1990-2007.



Source: Renewable Fuels Association (2008)

The general objective of this study was to determine spatial and temporal price relationships in distiller's grain (DG) markets. Particular objectives include estimating the extent of cointegration in spatial DG markets, determining whether price leadership is present, and quantifying risk present in hedging DG prices using existing futures contracts. Assessment of spatial cointegration provides important information regarding the spatial market for DG. If spatial markets are cointegrated, then prices tend to follow each other and arbitrage opportunities across markets are limited. If markets are not cointegrated, then they are operating somewhat independently of each other, suggesting opportunities for market arbitrage or selectivity by buyers. If centers of price leadership are present, and markets are cointegrated, this indicates market developments in dominant markets provide considerable information about expected price movements at satellite markets. If centers of price leadership are not present, then the markets discover information simultaneously and do not systematically react to information from dominant market locations. Futures markets are important to consider in this analysis because futures markets are highly visible, well developed, and are central markets. DG futures markets do not exist, but actively traded corn and soybean meal (SBM) futures are the most probable substitutes for DGs so they are included in the analysis. Finally, the ability to offset DG price risk using corn and soybean meal futures is incorporated into the analysis to quantify the strength of price relationships for these substitutes and to determine whether existing futures markets provide viable cross hedging opportunities for DGs.

The primary contribution of the current research is an evaluation of spatial market relationships and associated price discovery in the emerging DG markets. No published studies have provided this information which is central to assessing market efficiency. Also, this research will build upon previous DGs cross hedging studies by increasing the number of market locations included in the analyses to gain a broader geographic assessment and updating the data to include recent price information that incorporates data since the surge in ethanol production. Increasing the number of locations and including data from multiple sources provide a more representative set of price quotes from DG markets.

Literature Review

Distiller's grain prices and spatial markets have not been widely analyzed. Completed studies have assessed cross hedging potential using existing futures contracts for corn and SBM. Early work by Miller (1982) some 25 years ago concluded that cross hedging distiller's grain in corn and SBM futures reduced risk. Coffey, Anderson, and Parcell (2000) concluded that cross hedging corn gluten feed, and DG using corn and SBM futures contracts was unsuccessful in reducing price risk. Brinker, Parcell, and Dhuyvetter (2007) found that SBM futures are important to include with corn for DG cross hedging, as it holds 20-40% of the hedging weight. Furthermore, their results demonstrated that inclusion of both SBM futures and corn futures effectively reduces risk when cross hedging DG.

Price discovery dynamics have been widely evaluated for several commodity markets. Mattos and Garcia (2004) investigated relationships of cash and futures in thinly traded markets. Their analysis of futures markets in Brazil was associated with developing markets and circumstances where liquidity can be problematic. Results of their cointegration analyses illustrated that contracts with greater trade volume were more likely to demonstrate long-run equilibrium relationships, and therefore be cointegrated. However, thinly traded contracts, such as corn, did not exhibit a relationship between cash and futures prices. Nonetheless, they concluded that an unexpectedly low volume of trades were needed to facilitate information flow between cash and futures markets.

Several studies have examined spatial market integration for numerous agriculture commodities (e.g. Djunaidi et al. (2001); Goodwin and Piggott (2001); Goodwin and Schroeder (1991); Hudson et al. (1996); Pendell and Schroeder (2006); and Yang and Leatham (1998)). Djunaidi et al. assessed spatial price relationships and efficiency in the rice industry, specifically long grain rice. Their analysis evaluated markets in Arkansas, California, Louisiana, Mississippi, and Texas from 1986 to 1998. Through cointegration tests, they concluded that prices in Arkansas and Texas, Louisiana and Mississippi, were cointegrated, and therefore exhibited long run equilibrium relationships. Furthermore, they concluded that markets in the Southeast were efficient in terms of price discovery. They suggested the California market functions in a different manner due to the local demand and physical characteristics, rather than geographic location. Yang and Leatham (1998) evaluated daily futures price quotes for wheat, corn, oats, and soybeans from 1992 to 1995. They concluded that the four respective markets were not cointegrated when using bivariate models. Hudson et al. (1996) used cash prices in Texas and Oklahoma to evaluate the price relationships of cotton cash and futures markets. They employed cointegration and error-correction models to determine the extent and direction of price information flow. Finding cointegration between the two market locations in two of the four years, led them to conclude that the cash and futures market were limitedly related.

Methodology

To understand spatial price dynamics in the DG market, tests for the presence of cointegration are utilized. Cointegration has been a common practice used to evaluate long-run spatial market equilibrium relationships that may exist between two or more price series. Markets that are cointegrated do not diverge from one another over time, and therefore are considered to have a long-run equilibrium relationship. In contrast, if the price series' are not cointegrated, this suggests that the markets are spatially segmented (Pendell and Schroeder (2006)).

The popular cointegration testing framework as outlined by Engle and Granger (1987) was followed in this analysis. Enders (1995) provides guidelines for the procedures that were applied here. The initial step, determination of stationarity in the individual price series, was conducted by implementing the augmented Dickey-Fuller (ADF) test. The ADF is used to test for the presence of a unit root in a price series, and is exhibited by:

$$(1) \qquad \Delta y_t = -\varphi y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t\text{-}i} + \varepsilon_t \quad ,$$

where y_t is an individual price series, Δ signifies a differencing process, φ and β_1 are slope coefficients, and ε_t is a random disturbance term. The appropriate lag length selected was based upon the minimized Akaike information criterion (AIC). The null hypothesis is that φ is equal to zero, where failure to reject the null indicates the series is nonstationary in levels. Furthermore, the individual series become stationary by a differencing process.

To conduct the test for cointegration in a bivariate model with diesel price as an exogenous variable, x, to account for transportation costs, an ordinary least-squares regression is carried out on two price series,y_{1t} and y_{2t} as:

$$(2) \qquad y_{1t} = \beta_0 + \beta_1 y_{2t} + \beta_2 x_{t\text{-}1} + e_t \, .$$

The parameter estimates from (2) are then used to find $\hat{e}_t$, and are rearranged as:

$$(3) \qquad \hat{e}_t = y_{1t} - \beta_0 - \beta_1 y_{2t} - \beta_2 x_{t\text{-}1}.$$

To complete the cointegration evaluation, an ADF is conducted on the saved residuals, $\hat{e}_t$, as follows:

$$(4) \qquad \Delta e_t = -\varphi e_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta e_{t-1} + \varepsilon_t \ .$$

Detection of a unit root upon completion of the ADF on equation (4) suggests that the two price series, y_{1t} and y_{2t} are not cointegrated. Another form of this statement could be; if the error term is deemed stationary by completing an ADF and φ is not statistically different from zero, then the two price series are said to be cointegrated of the order (1, 1). This suggests the prices at the specified market locations are spatially integrated. Multi-variate cointegration, as opposed to bivariate cointegration, can also be performed testing for multiple cointegrating vectors. However, because collinearity among prices and interpreting multi-variate cointegration results is difficult, this work follows the procedures used in many such spatial market integration studies (e.g., Djunaidi et al. (2001); Goodwin and Piggott (2001); Goodwin and Schroeder (1991); Hudson et al. (1996); Pendell and Schroeder (2006); and Yang and Leatham (1998)) and implement bivariate cointegration tests.

Once the presence of cointegration is evaluated, vector autoregressive models are estimated to determine the speed of price adjustment and price leadership among market locations. Error correction models that included errors from (3) are used to avoid model misspecification as:

$$\text{(5a)} \qquad \Delta y_{1t} = \alpha_1 + \alpha_{1y}\hat{e}_{1t\text{-}1} + \sum_{i=1}^{k} \alpha_{11i}\Delta y_{1t\text{-}i} + \sum_{i=1}^{k} \alpha_{12i}\Delta y_{2t\text{-}i} + \varepsilon_{1t} \text{ , and}$$

$$\text{(5b)} \qquad \Delta y_{2t} = \alpha_2 + \alpha_{2y}\hat{e}_{1t\text{-}1} + \sum_{i=1}^{k} \alpha_{21i}\Delta y_{1t\text{-}i} + \sum_{i=1}^{k} \alpha_{22i}\Delta y_{2t\text{-}i} + \varepsilon_{2t} \text{ ,}$$

where α_{1y} and α_{2y} are estimated speed-of-adjustment coefficients that allow the time required to return to equilibrium from a divergence to be measured. Here, the absolute value of the speed-of-adjustment estimate is used to determine the rate of adjustment. As the magnitude of the speed-of-adjustment coefficient estimate approaches one, the reaction time is faster relative to when the estimate is near zero. A speed-of-adjustment estimate of zero would imply no response.

Lastly, an analysis of cross hedging DGs via corn and SBM futures contracts analysis is done using ordinary least-squares regression. Through this procedure, estimates for cross hedge ratios are obtained using:

$$\text{(6)} \qquad \Delta y_{it} = \beta_0 + \beta_1 \Delta Corn_t + \beta_2 \Delta SBM_t + e_t \text{,}$$

where i represents each respective market locations. Justification for the structural format of the cross hedge is that individual series were found to be non-stationary in levels, therefore it is appropriate to employ the model in first differences. The inclusion of both futures contracts is reasoned by Brinker, Parcell, and Dhuyvetter (2007), as DGs are a corn-derived product, but the protein content is similar to that of SBM, suggesting DG may be used as either an energy or protein source in animal diets. Thus, a combination of corn and SBM futures was chosen for the cross hedging feasibility analysis.

Data

DG prices from a large number of spatial markets covering numerous years are not publicly available. Therefore, data used in this analysis are a compilation of public sources and private sources that include the USDA Agricultural Marketing Service (AMS) weekly feedstuff's report, *Feedstuff's* magazine, and the University of Missouri's (MU) dairy extension service weekly price quotes. The AMS data include the location of Lawrenceburg, IN. *Feedstuff's* data include prices from Atlanta, GA; Buffalo, NY; Chicago, IL; Los Angeles, CA; Okeechobee, FL; Portland, OR; and Minneapolis, MN, and the MU data include Muscatine, IA; Atchison, KS; and

Macon, MO. A spatial representation of all market locations is demonstrated in Figure 2.2. The DG market prices represent spot price quotes, though the characteristics of the quotes vary by source. Data obtained from AMS and MU are plant-level prices (i.e., the quote comes directly from an ethanol plant producing DG). The *Feedstuff's* prices are obtained from grain merchandisers, meaning the prices may include freight to the location, as well as a margin for the trading firm. The DG prices are weekly quotes in dollars per ton, covering the period from January 2001 through December 2007. Weekly average settlement prices in dollars per bushel for corn and dollars per ton for SBM nearby futures contracts are Chicago Board of Trade quotes obtained from Commodity Research Bureau (CRB).

Figure 2.2 Spatial Representation of DDG Market Locations.

Results

The first step in analysis of spatial DG price discovery was to determine whether the individual price series were stationary. All of the weekly price series were non-stationary in levels over the six-year time period. The stationarity tests were estimated using the ADF in SAS under the structural format that included a constant, but no trend. All of the price series were stationary in first-differences. Therefore, the cointegration technique was appropriate to employ in price levels.

Table 2.1 reports the results of pair-wise cointegration tests for each pair of DG market locations and the corn and SBM futures markets. There were 35 of 78 (45% of all combinations) market location price pairs cointegrated at the 5% level. Some locations such as Lawrenceburg, Macon, and Minneapolis revealed frequent cointegrated pairs. Minneapolis was cointegrated with the majority of the other market locations. Minneapolis was the only DG market cointegrated with the corn and SBM futures markets, suggesting that a long run equilibrium relationship between Minneapolis and each of the respective futures markets exists. This may be spurious as corn and SBM futures are not cointegrated with each other. Alternatively, some DG pricing involves formula prices based on corn prices and finding cointegration of DG with corn prices is consistent with that practice. However, most other DG market locations are not cointegrated with corn futures, indicating formula pricing of DG with corn is either not consistent or not a dominant practice. Similarly, because most of the locations are not cointegrated with SBM, it too can be removed from consideration as a dominant practice utilized by DG market locations in their price formulation.

Table 2.1 Bivariate Cointegration Test Results for Weekly DDG Markets, 2001-2007.

	Dependent variable											
Independent	**Atchison**	**Atlanta**	**Buffalo**	**Chicago**	**Lawrenceburg**	**Los Angeles**	**Macon**	**Minneapolis**	**Muscatine**	**Okeechobee**	**Portland**	**Corn**
Atchison												
Atlanta	12.76*											
Buffalo	6.76	10.69										
Chicago	10.15	12.05	12.05									
Lawrenceburg	20.47*	22.79*	8.11	22.17*								
Los Angeles	5.92	30.51*	9.74	11.89	23.79*							
Macon	21.48*	22.85*	7.84	24.64*	36.08*	22.66*						
Minneapolis	26.54*	29.42*	9.06	23.95*	37.37*	19.64*	18.39*					
Muscatine	9.27	17.39*	8.78	11.88	19.75*	20.71*	13.30*	18.83*				
Okeechobee	10.13	N/A	8.13	11.36	N/A	23.35*	20.51*	20.42*	15.08*			
Portland	5.03	11.92	10.16	11.15	10.85	6.38	20.61*	10.20	9.49	12.50*		
Corn	10.12	13.58*	6.81	8.11	8.05	7.58	9.54	13.25*	5.57	15.58*	5.80	
SBM	11.61	10.66	11.19	10.17	23.22*	12.15	16.04*	15.94*	12.85*	11.09	6.86	5.46

* Denotes statistical significance at the 5% level

** Trace test critical value is 12.21

N/A represents models where errors are not white noise up to 50 lags

The presence of cointegrated markets leads to the implementation of an error correction model, structured in the form of vector autoregressive analyses. Because not all markets were cointegrated with high levels of statistical confidence, error correction models (ECM) were employed only for cointegrated market pairs. ECM estimates from market pairs which are not cointegrated are irrelevant, because there is not a long-run relationship to evaluate. Granger causality results, as seen in Table 2.2, show that considerable bi-directional causality is present in the DG markets. The causality results do not reveal a dominant DG price discovery market location. The Macon and Minneapolis markets, cointegrated more often than other markets, generally were Granger-caused by the other market locations and Granger-caused price changes at all other market locations. Additionally, Lawrenceburg frequently did not Granger-cause the other market locations, while it was commonly Granger-caused by the other locations, suggesting that it might be a follower in price discovery. Understandably, the corn and SBM futures markets lead the DG market locations with little feedback.

Table 2.2 Granger Causality Test P-Values for Weekly DDG Markets, 2001-2007.

	Atchison	Atlanta	Buffalo	Chicago	Lawrenceburg	Los Angeles	Macon	Minneapolis	Muscatine	Okeechobee	Portland	Corn	SBM
Atchison		0.0000*	-	-	0.0000*	-	0.0000*	0.0000*	-	-	-	-	-
Atlanta	0.0000*		-	-	0.0000*	0.0011*	0.0000*	0.0000*	0.0000*	-	-	0.2368	-
Buffalo	-	-		-	-	-	-	-	-	-	-	-	-
Chicago	-	-	-		0.0000*	-	0.0009*	0.0019*	-	-	-	-	-
Lawrenceburg	0.1299	0.1045	-	0.0869		0.1328	0.0012*	0.2873	0.1324	-	-	-	0.6295
Los Angeles	-	0.0000*	-		0.0000*		0.0000*	0.0000*	0.0000*	0.0000*	-	-	-
Macon	0.0000*	0.0006*	-	0.0572	0.0000*	0.0004*		0.0003*	0.0015*	0.0000*	0.0002*	-	0.2778
Minneapolis	0.0000*	0.0000*	-	0.0004*	0.0000*	0.0000*	0.0000*		0.0000*	0.0000*	-	0.2002	0.0410*
Muscatine	-	0.0096*	-	-	0.0000*	0.4984	0.0000*	0.0011*		-	-	-	0.6962
Okeechobee	-	-	-	-	-	0.0032*	0.0005*	0.0019*	0.0003*		0.0165*	0.3497	-
Portland	-	-	-	-	-	-	0.0000*	-	-	0.0000*		-	-
Corn	-	0.0000*	-	-	-	-	-	0.0000*	-	0.0000*	-		-
SBM	-	-	-	-	0.0000*	-	0.0000*	0.0000*	0.0000*	-	-	-	

* Denotes statistical significance at the 5% level
** Table is read as row causing the column

Speed-of-adjustment coefficients were estimated to determine how quickly markets respond to deviations from spatial equilibrium (Table 2.3). Both estimates, α_{1y} and $\alpha_{2y,}$ of the speed-of-adjustment coefficients are reported in the tables, though the absolute values are used in interpretation. The closer the absolute value of the speed-of-adjustment estimate is to 1.0 signifies that a full price correction occurs within one week. In contrast, an estimate close to 0.0 indicates a very slow market response to a shock in another market. The speed-of-adjustment coefficient estimates range (in absolute value) from 0.0001 to 0.1691 suggesting that the overall reaction time of disequilibrium across the spatial markets is slow with less than 17% of the full adjustment occurring within a week across all market locations.

Table 2.3 Error Correction Model Speed-of Adjustment Coefficient Estimates for Weekly DDG Markets, 2001-2007.

	Dependent variable												
Independent	**Atchison**	**Atlanta**	**Buffalo**	**Chicago**	**Lawrenceburg**	**Los Angeles**	**Macon**	**Minneapolis**	**Muscatine**	**Okeechobee**	**Portland**	**Corn**	**SBM**
Atchison		0.0695	-	-	0.0898	-	0.1271	0.0866	-	-	-	-	-
		(0.0205)	-	-	(0.0191)	-	(0.0214)	(0.0172)	-	-	-	-	-
Atlanta	-0.0590		-	-	-0.1355	0.0861	-0.1539	0.0735	-0.0766	-	-	0.0004	-
	(0.0238)		-	-	(0.0283)	(0.0213)	(0.0315)	(0.0147)	(0.0187)	-	-	(0.0003)	-
Buffalo	-	-		-	-	-	-	-	-	-	-	-	-
	-	-		-	-	-	-	-	-	-	-	-	-
Chicago	-	-	-		-0.1031	-	-0.1290	0.0726	-	-	-	-	-
	-	-	-		(0.0265)	-	(0.0269)	(0.0184)	-	-	-	-	-
Lawrenceburg	0.0221	-0.0275	-	-0.0199		-0.0029	-0.1295	0.0543	-0.0270	-	-	-	0.0342
	(0.0157)	(0.0203)	-	(0.0287)		(0.0227)	(0.0350)	(0.0250)	(0.0198)	-	-	-	(0.0239)
Los Angeles	-	-0.0642	-	-	-0.1538		-0.1691	0.1511	-0.0838	0.1410	-	-	-
	-	(0.0165)	-	-	(0.0245)		(0.0339)	(0.0307)	(0.0197)	(0.0363)	-	-	-
Macon	0.0143	-0.0091	-	0.0265	0.1625	-0.0565		0.1256	-0.0040	0.0281	0.0266	-	0.0171
	(0.0171)	(0.0223)	-	(0.0280)	(0.0320)	(0.0310)		(0.0445)	(0.0141)	(0.0332)	(0.0297)	-	(0.0314)
Minneapolis	-0.0019	-0.0131	-	-0.0281	-0.1318	0.0746	-0.1074		-0.0353	0.0610	-	-0.0001	0.0324
	(0.0138)	(0.0103)	-	(0.0191)	(0.0238)	(0.0284)	(0.0435)		(0.0146)	(0.0279)	-	(0.0003)	(0.0298)
Muscatine	-	0.0113	-	-	0.1290	0.0258	0.0677	0.0664		0.0366	-	-	0.0409
	-	(0.0186)	-		(0.0268)	(0.0249)	(0.0195)	(0.0200)		(0.0341)	-	-	(0.0348)
Okeechobee	-	-	-	-	-	-0.0573	-0.0965	-0.0692	-0.0577		0.0445	0.0004	-
	-	-	-	-	-	(0.0222)	(0.0228)	(0.0192)	(0.0164)		(0.0148)	(0.0004)	-
Portland	-	-	-	-	-	-	0.1228	-	-	-0.0503		-	-
	-	-	-	-	-	-	(0.0285)	-	-	(0.0213)		-	-
Corn	-	-0.0313	-	-	-	-	-	-0.0592	-	-0.0904	-		-
	-	(0.0095)	-	-	-	-	-	(0.0153)	-	(0.0236)	-		-
SBM	-	-	-	-	-0.0625	-	-0.0728	-0.0591	-0.0459	-	-	-	
	-	-	-	-	(0.0134)	-	(0.0167)	(0.0158)	(0.0135)	-	-	-	

* Values in parenthesis are standard errors

Cross hedging analyses for DGs using corn and SBM futures contracts for price risk reduction varied noticeably by location. Analysis were conducted using only corn or just SBM futures, though the results were inferior to those of using both commodity contracts (lower R-squared and larger RMSE). This is consistent with Coffey, Anderson, and Parcell (2000) who found that individually a corn or a SBM futures contract does not appear to capture the variability in the cash DG market as well as the two commodity prices together. Therefore, the focus was on using both corn and SBM futures contracts to hedge DG. The coefficient estimates are reported in Table 2.4. Using a combination of the two futures contracts does not provide viable cross hedging over the six year time span. The largest adjusted R-squared is for the Los Angeles market at only 0.128. The low explanatory power indicates poor cross hedging opportunity in corn and SBM futures for DG. The results indicate less potential than those of Coffey, Anderson, and Parcell who used data from 1991 to through 1998. This indicates the relationship between DG and corn and SBM futures holds less strength in recent years than in the past.

Table 2.4 DDG Cross Hedging Estimates using Corn and SBM Futures, Weekly 2001-2007.

Location	Intercept	Corn	SBM	Adj. R^2
Atchison	0.220	2.905	0.064	0.033
	(0.167)	(0.138)	(0.010)	
Atlanta	0.192	1.276	0.070	0.037
	(0.168)	(0.455)	(0.001)	
Buffalo	0.052	5.546	0.086	0.067
	(0.767)	(0.011)	(0.001)	
Chicago	0.140	4.166	0.046	0.016
	(0.506)	(0.108)	(0.166)	
Lawrenceburg	0.194	-1.101	0.009	-0.005
	(0.376)	(0.683)	(0.795)	
Los Angeles	0.136	7.782	0.111	0.128
	(0.420)	(0.000)	(0.000)	
Macon	0.074	9.157	0.067	0.073
	(0.713)	(0.000)	(0.032)	
Minneapolis	0.092	5.531	0.096	0.061
	(0.637)	(0.022)	(0.002)	
Muscatine	0.094	5.027	0.067	0.070
	(0.515)	(0.005)	(0.003)	
Okeechobee	0.210	0.839	-0.023	-0.005
	(0.494)	(0.824)	(0.629)	
Portland	0.115	6.342	0.104	0.079
	(0.548)	(0.007)	(0.000)	

Notes: The numbers in the parentheses are P-values

Conclusions

The DG market has expanded rapidly in recent years with the growing bio-fuels industry. Despite its growing importance, the DG market is still developing and publicly available market data are sparse. This study was undertaken to gain insight into DG spatial and temporal price efficiency and opportunity for risk management using existing futures markets. Slightly under half of pair-wise DG market comparisons were cointegrated indicating that spatial arbitrage opportunities exist. Furthermore, spatial proximity of the markets was not related to cointegration indicating distance between the markets was not a determinant of strength of price relationship. This means that DG buyers would benefit from shopping around at multiple markets for DG price quotes when buying DG.

Though the DG markets are not generally cointegrated, they are not independent. Granger causality revealed considerable bi-directional information flow with no single or set of markets leading discovery. This suggests that there is not a single dominant market location. Furthermore, the overall slow speed-of-adjustment across markets indicates DG markets do not rapidly adjust to changes in prices at other locations.

Cross hedging DG via corn and SBM futures contracts does not appear viable using recent data. This suggests some alternative form of price risk management will be necessary in the DG market. Current poor cross hedging opportunity with existing futures contracts might encourage forward pricing or development of a DG futures contract.

Collectively, the study results suggest a thin and somewhat information-starved DG market. Prices that are not strongly cointegrated across location and slow speed of adjustments indicate distiller's grain markets are not reacting to evolving information at other locations quickly. Though, feedback in Granger causality does suggest some spatial information flow is present.

Opportunities for further research in the DG market are vast. As the market continues to develop and evolve, both the quantity and quality of data will likely improve. Because the market is rapidly evolving, isolation of different (shorter and more recent) time periods could potentially show stronger, more prevalent relationships. Also, an analysis of similar products, wet distiller's grains and or modified-wet distiller's grains, is needed for a more comprehensive evaluation. The type of information needed to enhance distiller's grain market efficiency is a particularly important concern for future research.

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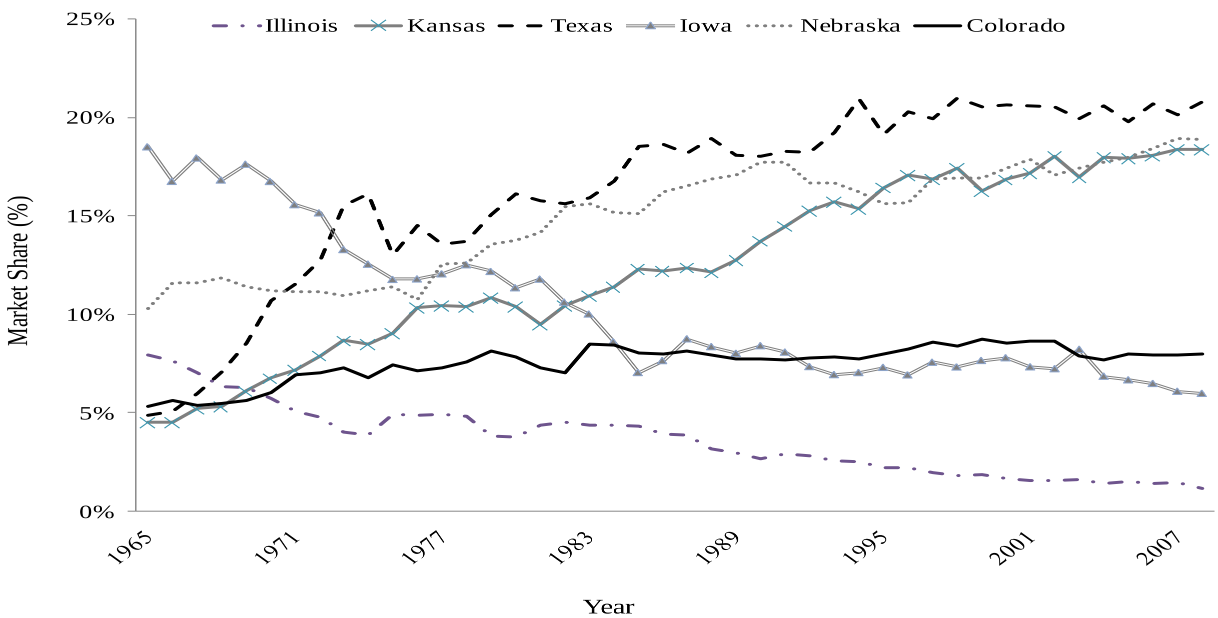
CHAPTER 3 - Shifting Regional Cattle Feeding Comparative Advantages: Steam Flaking Cost Estimation and Distiller's Grain Impacts

Record production of corn-based ethanol has occurred each of the last seven years, creating a noticeable increase in the demand for corn. Escalated competition for feed grains is causing substantial restructuring in the cattle feeding industry. In particular, high feed grain prices have contributed to substantial losses for cattle feeders over the past 18 months and longer term regional shifts in grain and ethanol co-product distiller's grains prices are creating important implications regarding regional costs of production and comparative advantages for cattle feeding.

Since the mid 1960's, cattle feeding operations have grown substantially in Nebraska, Kansas and Texas while Iowa and Illinois lost market share (Figure 3.1). A number of factors contributed to the regional shift in commercial cattle feeding operations. Over time, economies of scale have contributed to feedlots expanding in size with immense investments in facilities. Large commercial feedlots in the Kansas and Texas regions have captured additional comparative advantages by investing in steam flaking feed processing systems, a multi-million dollar investment. Steam flaking is typically considered to be more economically feasible for larger commercial feed yards. Multiple studies (e.g., Schake and Bull (1981), and Macken, Erickson and Klopfenstein (2006)) show that the cost of steam flaking generally decreases as the size of the feedlot increases. The lower cost per unit of production is attributed to the increased efficiencies associated with economies of scale. One example of economies of scale is the steam generating boiler, a smaller feedlot with a single flaker typically needs just one boiler, however this boiler is likely large enough to handle a second flaker which would potentially double the output. The significant investment in steam flaking is motivated because steam flaking in traditional corn-based rations enhances expected feed efficiency by up to 17% over dry rolled corn (Barajas and Zinn (1998)). However, as inclusion of distiller's grain (DG) in the ration increases, the efficiency of steam flaking over dry-rolling disappears (May (2007)). As the performance enhancement associated with steam flaking diminishes, the comparative advantage of feed yards using steam flakers dissipates.

Figure 3.1 Colorado, Illinois, Iowa, Kansas, Nebraska, and Texas Annual Cattle on Feed Market Shares as a Percent of US Total, 1965-2008.



Source: National Agricultural Statistics Service (2008)

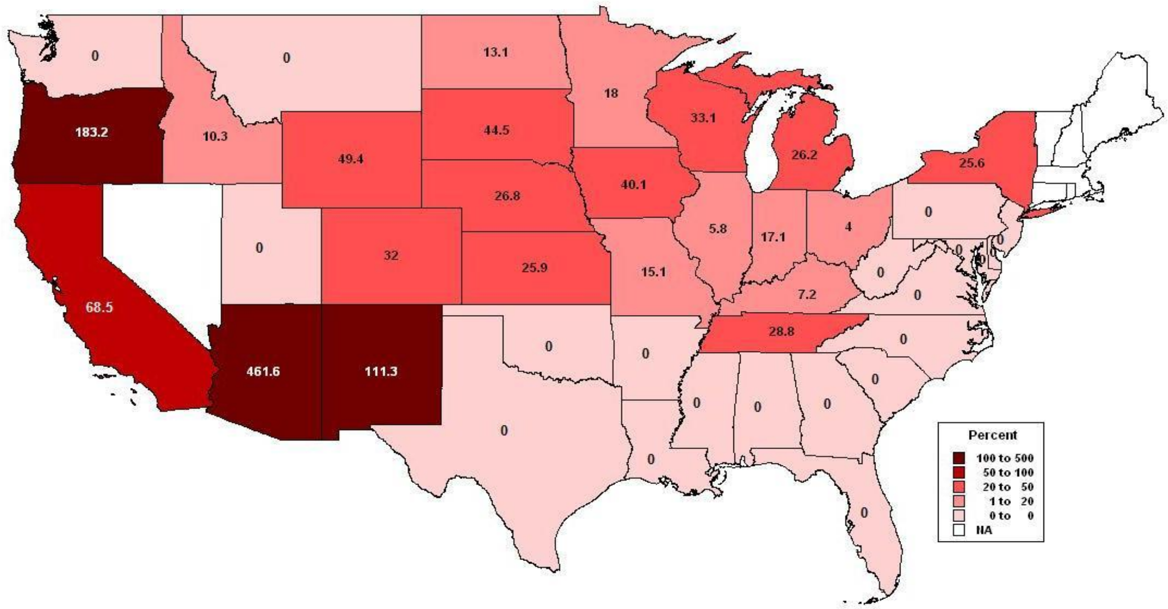
As a result of the increased demand for corn, increased availability of DG with potential utilization in cattle feeding rations, rising energy costs, and input price variability, central questions of cattle feeders in the high plains region include: 1) What is the cost of steam flaking relative to alternatives? 2) Should the steam flakers be shut down, and if so, what does that imply about relative cost of production? 3) What are the implications of relative cost shifts and regional cattle feeding comparative advantages? Addressing these questions is the objective of this research.

The current research contributes to the literature by evaluating regional cattle feeding sustainability under current production practices, namely steam flaked corn (SFC) and dry-rolled corn (DRC), with respect to the implications of increased corn based ethanol production. A vast array of research has been completed regarding the use of DG in cattle feeding, including animal performance, nutritional content, and economic efficiency of utilization. Though the intent here is not to determine optimal utilization of DG in cattle feeding, this is nonetheless a key issue facing the industry. This research builds on previous studies by utilizing empirical data to estimate costs of steam flaking corn. While previous literature has addressed this topic, the rising costs of energy necessitate updated and more detailed analysis of steam flaking costs than available from previous studies.

Background

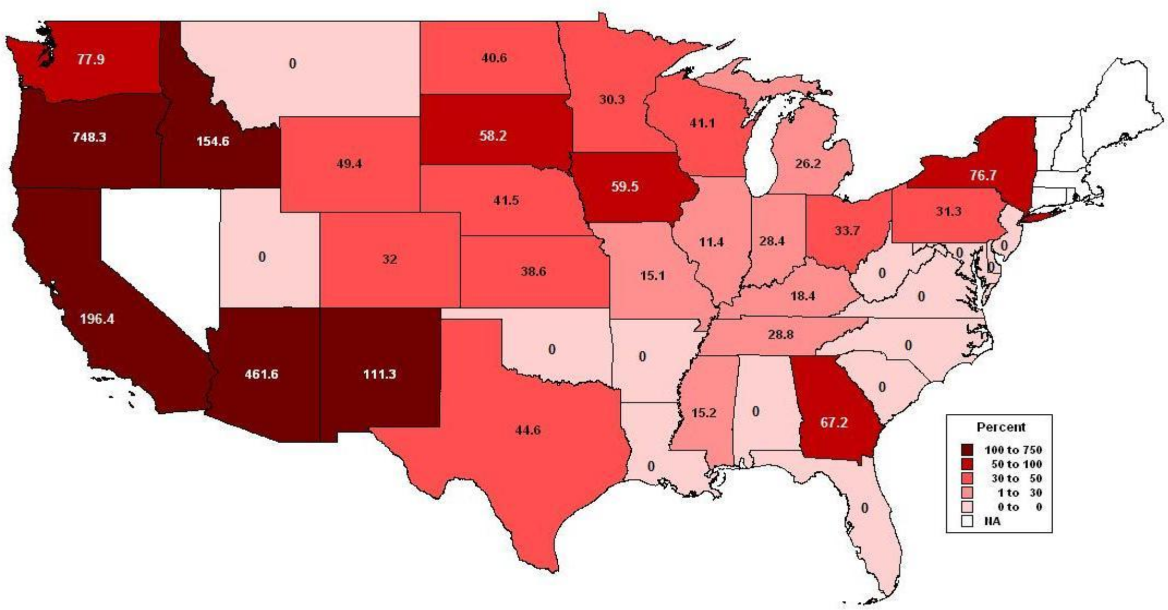
The commercial cattle feeding industry is facing a multitude of challenges regarding the viability and sustainability of current production practices. Traditionally, confined animal feeding has been characterized by heavy utilization of corn-based, high-concentrate diets. Moreover, substantial inclusion of corn in rations is commonplace to ensure efficient cattle weight gain. However, the feedstuffs market has been significantly altered due to the increased demand for corn by the ethanol industry. Figures 3.2 and 3.3 highlight the percentages of 2007 corn crop being used for current and anticipated future ethanol production levels. The state of Iowa is currently the largest corn-based ethanol producing state (RFA (2008)), as well as the largest producer of corn, based on 2007 National Agricultural Statistics Service (NASS) production data. Iowa could potentially use 40% of their corn crop for ethanol production given current capacities. However, with ethanol plants planned and under construction, the state could potentially use up to 59% of their 2007 corn crop in ethanol production.

Figure 3.2 Percent of 2007 Corn Production Potentially Utilized for Ethanol Production under Current Production Capacities by State.



Sources: National Agricultural Statistics Service (2008) and Renewable Fuels Association (2008)

Figure 3.3 Percent of 2007 Corn Production Potentially Utilized for Ethanol Production under Future Production Capacities by State.

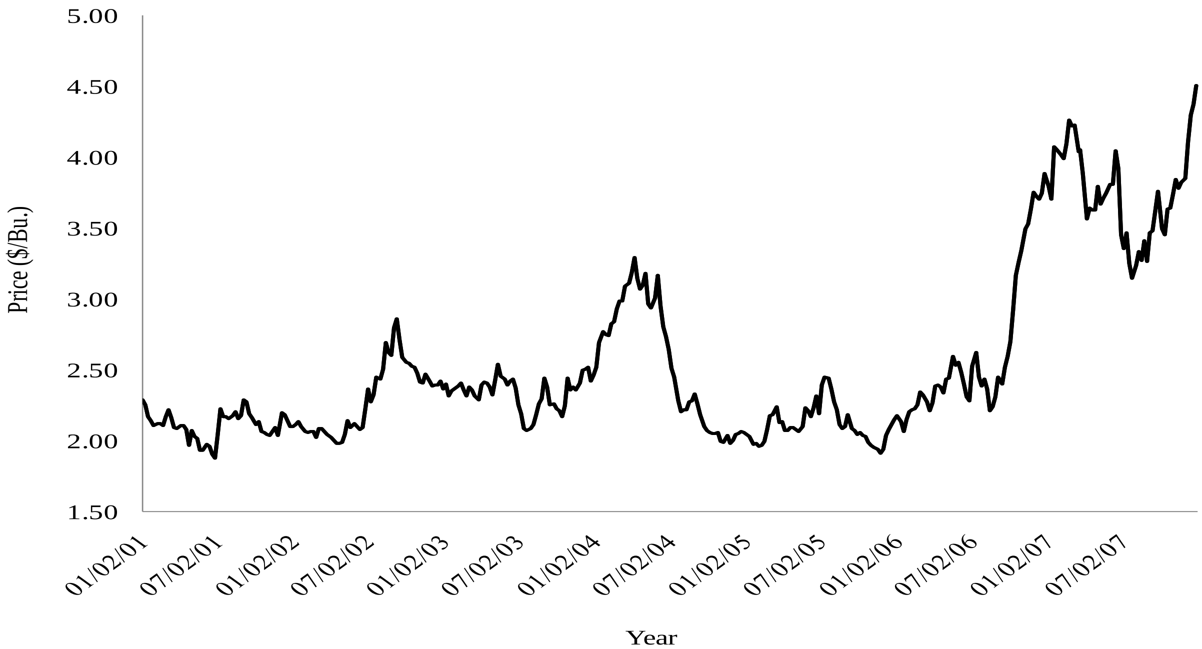


Sources: National Agricultural Statistics Service (2008) and Renewable Fuels Association (2008)

Recently corn prices and price volatility have increased substantially causing the economic efficiency of corn utilized in fed cattle production to emerge as an area of concern to cattle feeders (Figure 3.4). Consequently, the costs associated with current grain processing methods, also become significantly more important in regards to regional competiveness. The cattle feeding industry commonly uses a composite value, cost of gain[4] (COG), as a basis for comparison of performance under different scenarios and practices. This logic is verified in work by Anderson and Trapp (2000), who show that cost of gain is cointegrated[5] with corn price, suggesting that there is a long run equilibrium relationship between COG and the price of corn. With increased cost of steam flaking resulting from higher energy costs and with marked expansion of the corn based ethanol industry, shifts toward increased DG inclusion in fed cattle rations have been observed. The large influx of DG in cattle feeding rations has substantially and rapidly shifted the comparative advantage of cattle feeding associated with steam flaking. Figure 3.5 identifies the potential consumption of DG by all livestock for each state. Combining potential consumption with spatial DG production, Figures 3.6 and 3.7 show the percentages of their respective DG production that each state could potentially utilize. DG have become a key cattle feeding ingredient substituting for corn in feed rations. A body of published research in animal sciences has indicated that the comparative advantage of steam flaking relative to dry rolling is dramatically altered when DG is included in the diet (discussed below). Therefore, regional comparative advantages associated with steam flaking disappear and may shift cattle feeding to other regions of the country with increased inclusion of DG.

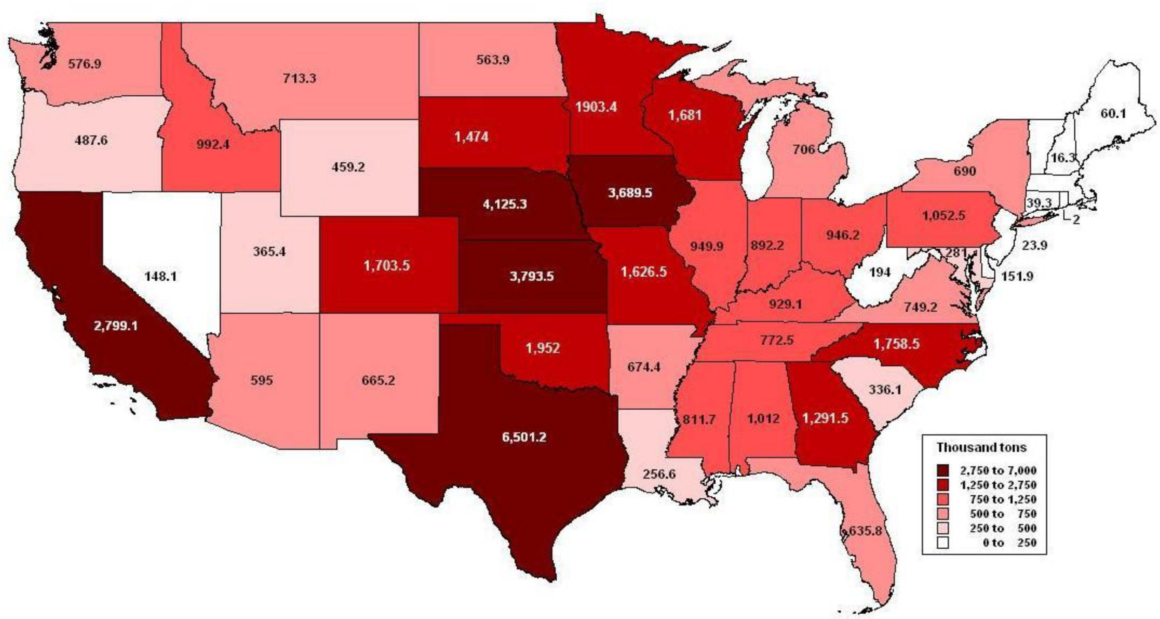
[4] Cost of gain is a standard industry statistic that explicitly states the cost of increasing the weight of an animal by one pound. While this number can have multiple cost components (yardage, medicine, insurance, etc.), for this analysis it is assumed that the only applicable cost is feed.
[5] Cointegration is an econometric modeling technique used to evaluate if two or more series, which individually are non-stationary, can be characterized as having a long-run equilibrium relationship.

Figure 3.4 Average Weekly Chicago Board of Trade Settlement Price of Nearby Corn Futures Contract, 2001-2007.



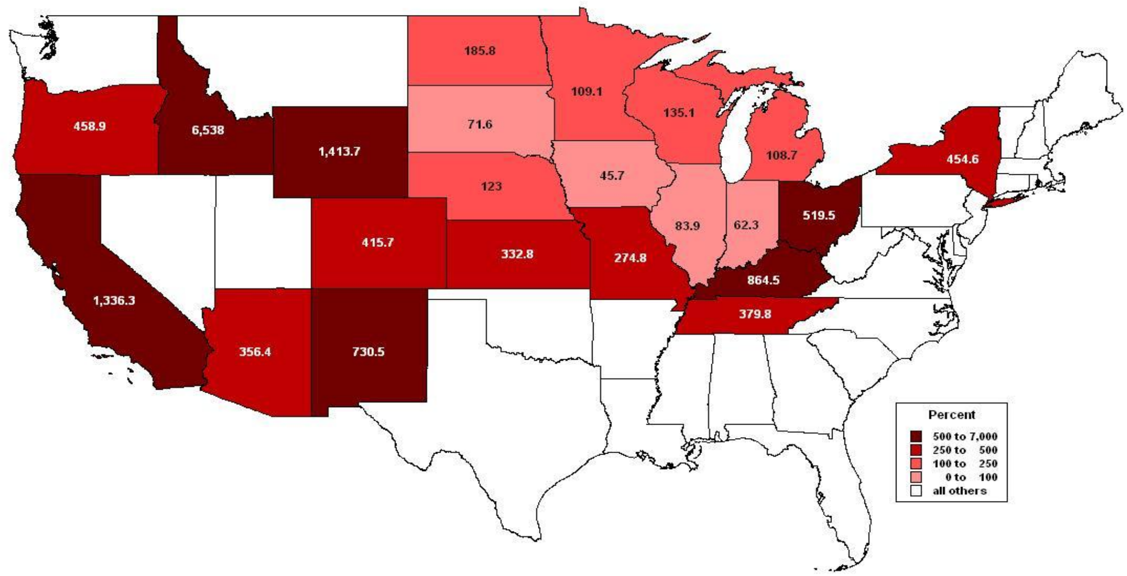
Source: Commodity Research Bureau database

Figure 3.5 Potential Consumption of DDG by Livestock for Select States.



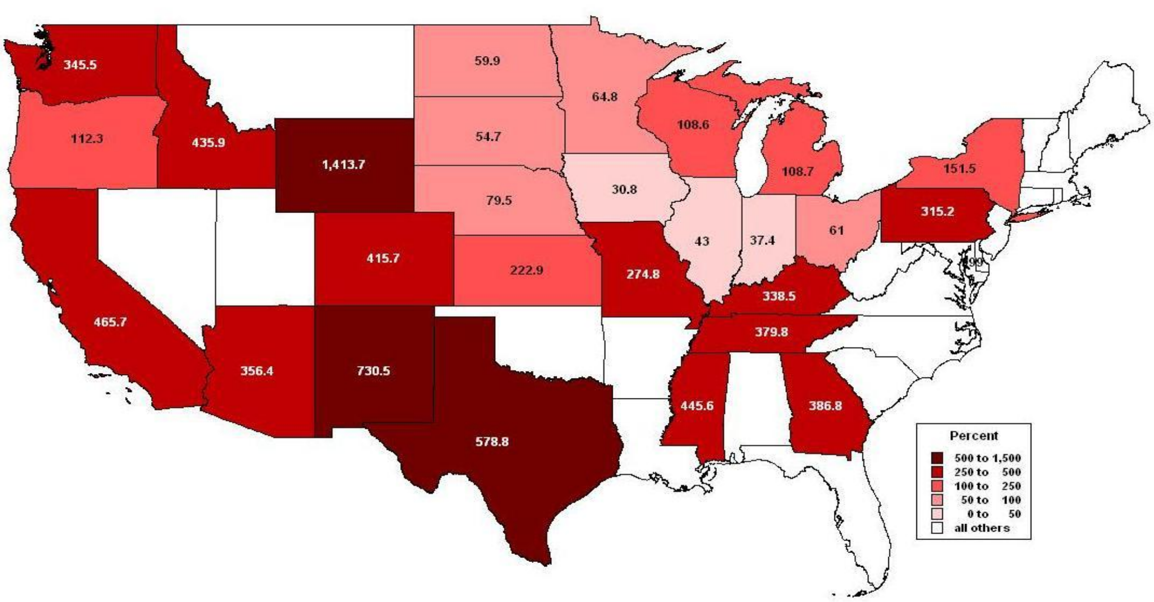
Sources: Dhuyvetter, Kastens and Boland (2005), National Agricultural Statistics Service (2008), and Renewable Fuels Association (2008)

Figure 3.6 Percentage of Current DDG Production Potentially Consumed by Livestock in Selected Ethanol Producing States.



Sources: Dhuyvetter, Kastens and Boland (2005), National Agricultural Statistics Service (2008), and Renewable Fuels Association (2008)

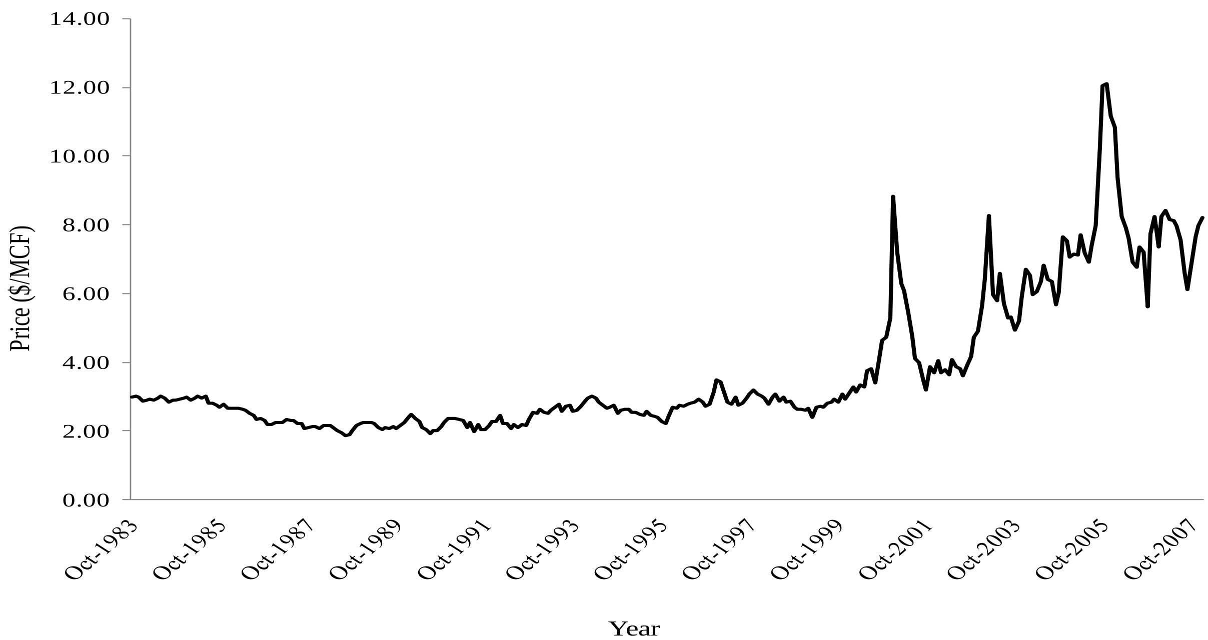
Figure 3.7 Percentage of Future DDG Production Potentially Consumed by Livestock in Selected Ethanol Producing States.



Sources: Dhuyvetter, Kastens and Boland (2005), National Agricultural Statistics Service (2008), and Renewable Fuels Association (2008)

Currently there are three primary methods of processing corn common to cattle feeders; dry rolling, high-moisture ensiling, and steam flaking. With respect to energy demand, dry rolling generally is the least expensive as the main energy input is electricity. Whereas, steam flaking requires an additional cost of fuel (usually natural gas) to operate the steam generating boiler. Furthermore, grain processing input costs have increased substantially, namely natural gas, a common fuel source to operate boilers. As seen in Figure 3.8, natural gas prices have increased noticeably since 2000. Natural gas price level and volatility have dramatically increased in the last seven years, suggesting that the cost of steam flaking has dramatically escalated and become less stable. For instance, natural gas price increased from $3.62 per million cubic feet (MCF) in August 2002 to $8.27 in March 2003, a change of 128% in just eight months. Additionally, the coefficient of variation from January 2001 to January 2008 is 29.7% signaling noteworthy variability in prices of this period.

Figure 3.8 US Average Monthly Industrial Natural Gas Price, October 1983 – January 2008 (1983-2000 estimated)



Source: Energy Information Administration (2008)

Note: The industrial price of natural gas was estimated for 1983-2000 time period because prior to 2001 it was classified as commercial use. Once the industrial price was created, agricultural firms were classified as industrial users.

The primary reasons for investing in a steam flaking system are to improve feed efficiency and create opportunities for inventory gain by increasing the moisture content of grain. Steam flaking corn (SFC) can increase feed efficiency by approximately 8-17% relative to dry rolling (DRC). Dry rolling is more commonly used in feedlots located in the corn-belt states such as Iowa and Nebraska. As a result, even with stronger corn basis relative to the corn-belt, feedlots located in the southwest high plains have enjoyed significant cost advantages relative to feeders located in the corn-belt. Though, as aforementioned the market environment is quickly changing this advantage.

Literature Review

In determining the optimal grain processing method, there are several key elements for a feedlot to consider including the cost of investment, anticipated animal performance, and regional cost differences associated with feedstuff procurement. For this work, only steam flaked corn and dry-rolled corn will be compared, though there are other substitutable methods. The expected performance difference between SFC and DRC has been extensively evaluated to analyze a multitude of factors, including dietary inclusion level, ration composition, and associative effects when feeding a given combination of SFC and DRC, a subset of these studies is summarized and provided above in Table 3.1. Owens et al. (1997) conducted a review of published literature evaluating the performance of fed cattle based on grain type and form of processing. The authors formulated base criterion so that the studies could effectively be compared, such characteristics identified were; grain type, the primary grain was a least 55% of the diet on a dry-matter basis, and only employed one form of grain processing in a given trial. The search identified 183 and 53 studies for SFC and DRC, respectively. Least squares means were utilized to determine the relative feeding advantages by grain type and processing method. The authors concluded that based on feed to gain ratio,[6] SFC is 10.4% more efficient relative to DRC in terms of animal weight gain. In other published research (Huck et al (1998), Barajas and Zinn (1998), Brown et al (2000), Ward et al (2000), Cooper et al (2001), Corona et al (2005), and Macken, Erickson and Klopfenstein (2006)), the average advantage of feeding SFC over DRC, in terms of the feed to gain ratio, nets about a 12% advantage, with reported benefits

[6] The feed to gain ratio is a commonly accepted industry statistic that computes the pounds of feed, on a dry matter basis, that need to be consumed for the animal to gain one pound of weight.

ranging from 7.5% to 16.9%. Based on the reviewed literature, it takes approximately 0.7 more pounds of corn on a dry-matter (DM) basis for the animal to gain a pound of weight when using DRC as opposed to SFC.

Table 3.1 Summary of Animal Performance Differences Associated with Steam Flaked and Dry Rolled Corn Reported by Previous Literature.

	Average Daily Gain (lbs)			Feed to Gain Ratio		
Study	DRC[a]	SFC[b]	Difference	DRC[a]	SFC[b]	Difference
Owens et al. (1997)[c]	3.20	3.15	-1.38%	6.52	5.84	10.40%
Huck et al. (1998)	4.01	4.32	7.69%	5.71	5.26	8.04%
Barajas and Zinn (1998)						
Trial 1	2.23	2.38	6.93%	7.94	6.94	12.66%
Trial 2	2.43	2.63	8.18%	7.65	6.35	16.91%
Brown et al. (2000)						
Trial 1	3.11	3.66	17.73%	5.83	4.89	16.09%
Trial 2	3.48	3.77	8.23%	5.56	5.15	7.50%
Ward et al. (2000)	3.42	3.70	8.19%	5.93	5.09	14.04%
Cooper et al. (2001)	3.61	3.60	-0.28%	6.15	5.64	8.30%
Corona et al. (2005)	3.00	3.13	4.41%	5.82	5.12	11.97%
Macken, Erickson, and Klopfentstein (2006)	4.23	4.34	2.60%	5.49	4.90	10.68%
Average	3.27	3.47	6.23%	6.26	5.52	11.66%
Minimum	2.23	2.38	-1.38%	5.49	4.89	7.50%
Maximum	4.23	4.34	17.73%	7.94	6.94	16.91%

[a]DRC represents dry-rolled corn

[b]SFC represents steam-flaked corn

[c]Reported values are least-square means

Investment and operating costs for a feed mill in a feedlot are generally quite different across DRC and SFC processing methods. A summary of DRC and SFC comparative cost literature is provided in Table 3.2. The time span covered by the studies is 25 years, signaling that the costs are not readily comparable. One method to account for this could be creating an index to inflate prices over time. However, the cost components have not increased at the same rate over time. An example of this is that natural gas costs in 1981 were assumed to be $2.00/ MCF, and as mentioned the prices recently have been over $12.00/ MCF (a six-fold increase). However, the same large relative increase has not been the case for labor. For example, McEllhiney (1981) assumed $10.00/hour and Macken, Erickson, and Klopfenstein (2006) used $15.00/ hour, an increase by a factor of 1.5. Furthermore, electricity was assumed to be the same price in both studies. Coupling the different growth rates with technological innovations, exemplifies the challenges with comparing cost estimates across studies, so prices are left as reported. Even though cost components vary in assumed levels across studies, all of the reviewed studies include repair / maintenance costs, electricity and natural gas (if SFC) utilities, labor, interest, depreciation, taxes, and interest. These factors are the essential components, though other costs not considered are administration fees (billing costs), and opportunity costs for time lost when repairs and maintenance occur.

Table 3.2 Summary of Grain Processing Costs ($/ton) on a Dry Matter Basis for Steam Flaked and Dry Rolled Corn Reported by Previous Literature.

Feedlot Size (head capacity)	5,000		20,000	
Processing Method	DRC[a]	SFC[b]	DRC[a]	SFC[b]
Bull and Schake (1980)	2.57	9.79	1.74	6.37
McEllhiney (1986)*	2.04	6.23	-	-
Cooper et al. (2001)	1.60	7.16	1.44	6.79
Macken, Erickson, and Klopfenstein (2006)	1.43	8.68	0.73	5.65
Average ($/ton)	1.91	7.97	1.30	6.27
Minimum ($/ton)	1.43	6.23	0.73	5.65
Maximum ($/ton)	2.57	9.79	1.74	6.79

[a] DRC represents dry-rolled corn

[b] SFC represents steam-flaked corn

* Reported values have been converted from as-fed to dry matter basis, with average moisture content assumed to be 14% and 20% for dry-rolled and steam flaked corn, respectively.

Early work by Bull and Schake (1980) evaluated corn and grain sorghum processing alternatives for feedlots located in Texas. They point out that grain input costs have a significant (75%) role in determining COG. This result coincides with findings of Anderson and Trapp (2000), signaling that one must consider grain price when analyzing processing method costs. Previous works (e.g. Bull and Schake (1980); Cooper et al. (2001); and Macken, Erickson and Klopfenstein (2006)) generally follow similar methods to estimate costs for both 5,000 and 20,000 head feedlot capacities for SFC and DRC as well as other feed processing methods such as ensiled high moisture corn. Obtaining cost and utilization estimates has typically been done by conducting personal interviews with either feedlot managers, consultants, or a combination of the two. The studies collectively conclude that when comparing the two processing methods, processing costs with steam flaking are substantially higher than with dry-rolling. Furthermore, the costs of both methods decline with increasing feedlot capacity, indicating significant economies of scale exist in feed processing technology. Similar to the studies discussed above, Brown et al. (2000) also report costs associated with SFC and DRC. However their estimates differ in composition in that they obtained actual utilization of electricity and natural gas under assumed unit costs, though they did not estimate maintenance/ repairs, labor, depreciation, surfactants, taxes, or insurance. They report that the cost of natural gas is $2.18/ton DM, and electricity costs $2.25/ton DM when producing SFC, while electricity costs for DRC are $0.417/DM ton. A comparison of these estimates to the group of studies that use assumptions for utilization and cost show that natural gas is comparable, though electricity costs are higher than assumed estimates based on empirical data. This suggests that the assumptions used by; Bull and Schake (1980), Cooper et al. (2001), and Macken, Erickson and Klopfenstein (2006), to form cost estimates are likely close to actual costs.

At what point should DG be included in a ration for cattle on feed? Several studies have evaluated the optimal inclusion rate of DG, both from an economic and nutritional (animal sciences) value basis. Recent work by Buckner et al. (2008) developed an interactive model for producers to use when considering the above question. The model requires inputs such as initial animal weight, expected end weight, the price of feeder cattle, the anticipated price received, and expected animal performance, to estimate expected returns, cost of gain, and lastly the returns associated with using by-products. Though the assumptions of the model limit widespread regional use, it does allow for producers within 100 miles of an ethanol plant who use DRC or high moisture corn, to evaluate potential outcomes of incorporating DG into their rations. Their results suggest that for WDG use, expected returns decrease as the location of the cattle feeder is farther and farther from an ethanol plant, though they suggest that up inclusion up to 50% WDG should return a positive value to the cattle feeder even if located 100 miles away. However, they conclude by noting that distance from an ethanol plant, type of by-product, and cost of the by-product relative to corn are the driving factors in the expected returns.

Similarly, Daley (2007) formulated least cost ration budgets for the leading cattle on feed states, Colorado, Kansas, Nebraska and Texas, with regard to by-product type as well as grain processing type (SFC or DRC) . In terms of cost of gain, they conclude that in all four states that a combination of 15% WDG and DRC resulted in the most cost efficient weight gain, though these results assume that the feedlot is within 200 miles of an ethanol plant. Jones et al. (2007) also estimate the optimal economic inclusion rate of DG in beef cattle diets, but consider just the cost of corn, and do not specify the processing type, however the results are still pertinent to this work. They estimate the impact of WDG and DDG simultaneously in a regression to predict average daily gain, with the coefficient estimates and corn price, the authors estimate the optimal net return with respect to the inclusion rate of DG. It is reported that if using DDG, that the optimal level is about 22%, and for WDG, the optimal level is increased to about 39%. Collectively these studies suggest that the inclusion DG is generally in the best interest of the producer, under the set of simulated circumstances.

Data

To collect data necessary to determine costs associated with grain processing, intensive feedlot visits were completed onsite to obtain actual charges incurred when using the steam flaking process. Visits were completed at 23 feedlots located in Kansas. The feedlots ranged in size from 10,000 head to more than 70,000 head on-feed capacity. The data collected included feedlot head capacity, detailed flaking density specifications, flaked throughput volume, as well as the number and size of both the flakers and boilers. Monthly costs and usage of electricity, natural gas, maintenance / repairs, and grain conditioner (surfactant), were collected. Monthly tons of steam flaked corn produced were also collected. Data to account for depreciation is difficult to obtain from feedlots because of ownership and employee turnover, and facility upgrades. An accurate representation of the original cost is quite difficult to assess. Therefore, through personal contact with a major mill construction company, current investment costs were obtained, the source requested to remain anonymous and thus is not reported.

The data collected from the feedlots cover a relatively short period of time. During the onsite visits, it was common for the bills (data) to be sent off either immediately or after a fiscal year end to an offsite location. Because many of the feedlots in the study are integrated corporations, there is generally a headquarters, elsewhere from the feed yards themselves. Therefore, the time period of data collected was either six or eighteen months, to ease the requirement of participation by the feedlot. The eighteen month data encompasses seventeen feedlots, while the six month data contains all 23 feedlots and is summarized in Table 3.3.

Table 3.3 Summary of Factors Associated with Data Collected on Grain Processing Costs ($/ton) on an as-fed Basis for Steam Flaked Corn.

	January 2007 - June 2007			January 2006 - June 2007		
Factor	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**
Natural Gas ($/ton flaked)	3.14	5.61	2.29	2.66	3.31	2.16
Electricity ($/ton flaked)	1.20	2.63	0.45	1.25	1.47	0.48
Surfactant ($/ton flaked)	0.37	0.65	0.00	0.46	1.24	0.00
Maintenance ($/ton flaked)	0.61	1.32	0.15	0.54	0.89	0.24
Variable Cost ($/ton flaked)	5.37	7.69	3.57	4.90	6.22	3.60
Labor Cost ($/ton flaked)	0.75	1.60	0.28	0.84	1.60	0.28
Depreciation Cost ($/ton flaked)	0.52	1.17	0.20	0.53	1.17	0.20
Fixed Cost ($/ton flaked)	1.28	2.42	0.48	1.28	2.42	0.48
Total Cost ($/ton flaked)	6.60	9.05	4.45	6.16	8.06	4.61
Electricity usage - kilowatt hours (kwh)/ ton flaked	20.68	65.85	6.96	18.50	38.06	7.36
Natural Gas usage- million cubic feet (MCF)/ ton flaked	0.37	0.47	0.16	0.34	0.42	0.19
Flaking density (lbs/bu)	27.5	24.5	30.5	27.5	24.5	30.5
Flaked corn (tons/ month)	7042.7	26482.3	2038.9	6175.3	14572.3	2777.3
Total horsepower of boilers	319.3	1,100	150	251.5	400	150
Feedlot capacity (head)	39,382	120,000	10,000	31,694	50,000	10,000

Production data for corn based ethanol were obtained from Renewable Fuels Association and aggregated to a state-level basis. Corn production data for the 2007 crop year were obtained from NASS for each state. Lastly, potential animal consumption of DG, by species (dairy cows, cattle on feed, beef cows, other cattle, breeding swine, market swine, layer poultry, broiler poultry, and turkeys), were obtained from Dhuyvetter, Kastens and Boland (2005), individual animal consumption was aggregated by state to obtain consumption levels.

Methodology

Benchmark cost estimation across feedlots is an important outcome from this analysis, as this procedure provides insight regarding individual components of the total costs of steam flaking, and allows for contemporary comparisons across feedlots. With a better understanding of the total cost of steam flaking, feedlots have necessary information to determine relative efficiency of their system. Furthermore, benchmark analysis allow feedlot managers to determine whether further enhancements should be made to increase the efficiency of their steam flaking system or consider abandoning the practice and leave the flaker set idle.

Benchmark analysis was completed for the 23 feedyards in which data were collected. In this process, there were two time periods analyzed corresponding to the data collected, January 2006 thru June 2007, and January thru June 2007. To create an incentive for feedyards to participate and openly share data, each participating firm received a comprehensive analysis of their steam flaking costs and a summary of the study averages (two sample reports are provided in Appendix A). In the benchmark process, averages of each of the factors contributing to total cost of steam flaking were computed. A ratio of each factor by firm was created by dividing the firms' average by the average of the other feedlots. Though this ratio does not allow for economies of scale or unique feedlot characteristics to be compared, it does provide production cost information relative to competitors. The information on relative performance is of significance because if a firm is the least cost producer, they have a cost advantage which might increase the sustainability of that feedlots' mill.

The process of steam flaking is generally homogeneous in nature, the concepts being water is heated to form steam which is added to grain, and then the steam-heated grain is rolled to create a flake. That being said, the setups of steam flaking systems vary widely from feedlot to feedlot. For instance, movement of flaked grain is sometimes done with a pneumatic system, other times by augers or conveyers, and sometimes simply by use of gravity. Therefore, when comparing utility consumption, depreciation, labor, and maintenance costs across firms, several assumptions have to be made. To accurately monitor utility consumption, flow meters would need to be installed for electrical and natural gas use by machines involved in the steam flaking process. Use of consumption flow meters is very intrusive, and takes significant time to capture variability. Instead of using flow meters here, monthly electrical bill totals were allocated in full to the cost of steam flaking. However, here too are large differences as some feedlots have the entire yard on one meter, while others have the mill on a different meter. This distinction was captured and is evaluated in Equation (2), it is noted, but not accounted for in individual benchmark reports prepared and sent back to the feedlots. Costs of utilities may vary based on usage agreements and other marketing strategies between the supplier and the feedlot, while this is an important issue; it too creates challenges when comparing firms. Maintenance and repair costs can be cyclical and vary based on management practices. Because the mill needs to run every day, shut-downs require planning and scheduling, which given the limited time span of the collected data can distort cost estimates. The depreciation cost represents the opportunity cost for replacement of the steam flaking section of the mill. Grain conditioners (surfactant) are often applied at different rates, based on the characteristics of the grain. Also, surfactant is an inventoried item which can create cost clusters in the data. Given this issue, surfactant costs and application was assumed to be a constant rate over time. Lastly, labor costs are obtained from annual salary estimates from each feedyard, and so the labor cost per ton is constant. Depending on the firm, this estimate can change significantly depending on the time of year.

The primary factors contributing to the cost of SFC are natural gas, and electricity (McEllhiney (1986), and Cooper et al (2001)). Therefore, to better understand influences of these two factors, ordinary least squares regression models were estimated to explain monthly energy use (dependant variables of monthly electric and natural gas bills, and kilowatt hours and million cubic feet of natural gas utilized in the steam flaking process) as a function of volume by month to assess seasonality (volume throughput per month times monthly binary variable), flaking density, and flaker or boiler specifications. The horsepower of electrical motors running the flaker, and the number of flakers was included in evaluating the electricity consumed, while the horsepower and the number of boiler(s) was included in the natural gas model. There is likely a relationship between the characteristics of the flaker and the boiler(s), though it is difficult to evaluate the impact of flaker characteristics on natural gas consumption, as well as the effect of boiler features on electricity consumption, so the two are modeled separately. The energy utilization models contain relevant variables to reveal information about economies of size, impact of flaking density, seasonal flaking energy variability, and management implications. The following equations are specified to estimate monthly energy use in steam flaking:

(1) $$MCF = \beta_0 + \beta_1*Jan + \beta_2*Feb + \beta_3*Mar + \beta_4*Apr + \beta_5*May + \beta_6*Jul + \beta_7*Aug + \beta_8*Sep + \beta_9*Oct + \beta_{10}*Nov + \beta_{11}*Dec + \beta_{12}*Prod + \beta_{13}*(Prod)^2 + \beta_{14}*(thp_b*num_b) + \beta_{15}*(thp_b*num_b)^2 + \beta_{16}*fd + \beta_{17}*surf + e$$

(2) $$KWH = \beta_0 + \beta_1*Jan + \beta_2*Feb + \beta_3*Mar + \beta_4*Apr + \beta_5*May + \beta_6*Jul + \beta_7*Aug + \beta_8*Sep + \beta_9*Oct + \beta_{10}*Nov + \beta_{11}*Dec + \beta_{12}*Prod + \beta_{13}*(Prod)^2 + \beta_{14}*(thp_f*num_f) + \beta_{15}*(thp_f*num_f)^2 + \beta_{16}*Stagger + \beta_{17}*Bill + \beta_{18}*fd + \beta_{19}*surf + e$$

Equations (1) and (2) are estimated over time and across feedlots in one combined stacked model. As such, each variable implicitly carries a time and feedlot subscript that is omitted for notational convenience. Notation for the above models is as follows:

- MCF: million cubic feet of natural gas used per ton
- KWH: kilowatt hours used per ton
- Month: monthly dummy variables
- Prod: steam flaked grain production (tons/month)
- thp_i: aggregate horsepower ($_f$ =flaker(s), $_b$ =boiler(s))
- num_i: number of machines used to flake ($_f$ =flakers, $_b$ =boiler)
- Stagger: binary variable for how the yard starts flaking motors (=0 if sequentially, =1 if simultaneously)
- Bill: dummy variable for electric utility bill, some feedlots have separate meters for the mill, and some have the entire feed yard on one meter (=0 if the mill is separate, =1 if entire feedlot)
- fd: flake density of steam flaked corn[7] (pounds/ bushel)
- surf: dummy variable for use of surfactant (0= if not used, 1= if used)

[7] As the value of flake density decreases, the amount of processing increases, that is a 24 pound/bu. flake is more extensively processed than a 26 pound/bu. flake.

These models are setup to evaluate and quantify the driving factors of energy consumption in a steam flaking system. The dependent variables are quantity usage rather than costs because of potential pricing agreements and or price differences between service providers. Thus, this approach allows for analyses across firms to compare energy utilization efficiencies. Furthermore, in (1) the focus is the boiler, because it is likely that the characteristics of the flakers have negligible impacts on monthly natural gas consumption, the driving factors are the properties of the boiler. Similarly, in (2) the flaker is the focus, because the boiler likely does not significantly impact electricity consumption. Monthly production variables allow for the relationship of seasonality and production flaked corn to be accounted for, especially for natural gas where the weather temperature could impact efficiency and therefore consumption. Each of the monthly production variables are anticipated to have a positive coefficient because as production of flaked corn increases, so will utility consumption. The wheat variable is included in both models because usage rates are expected to affected differently than when only flaking corn. The characteristics of wheat require that the feedlot reformat settings on flakers because the rolls of flakers must be moved closer together, thus potentially altering energy consumption. Wheat is expected to require more electricity usage to flake than corn so the coefficient is expected to be positive. In terms of natural gas, the impact of flaking wheat is uncertain, thus the expected sign on Wheat is unknown in that model.

Equations (1) and (2) include interaction variables to measure the effect of total flake production (all grains) and the total horsepower of either the flaker of the boiler. The logic for this is that as the total value of production and horsepower increases, the relative efficiency can be evaluated. A positive sign is expected on the production and horsepower interaction variable because as total value of the relationship of total production and total horsepower increases, energy consumption increases. The impact of the number of machines, either for the flaker or the boiler, is evaluated through another interaction variable. The relationship between production, horsepower, and the number of machines may impact the utilization of energy. For instance, are two- 150 horsepower (hp) boilers equivalent to one- 300 hp boiler? The sign on the interaction variable with production, horsepower, and number is expected to be positive for both electricity and natural gas usage, because as the number of machines is increased, more motors are required for flakers, and heat loss may be increased if multiple boilers are used.

Shutdown decisions are generally referred to by economists as the point where marginal cost exceeds marginal revenue. However, a feedlot generally needs some form of onsite grain processing system for efficient operation over an extended period of time. The opportunity cost, with respect to the costs and associated efficiencies of SFC and DRC, of substitute grain processing methods is appropriate to evaluate when considering the use of an alternative method. Thus, the critical decision point for a feed yard could be identified by equating the costs of gain for SFC and DRC. A key consideration also has to be cattle ownership; here ownership is assumed to be held by the feedlot[8]. Combining the feed to gain ratio, corn price and the costs of processing into a single equation, the alternative indifference cost level is calculated, and is shown below:

(3) $(F:G)_{DRC}*(P_C + P_{DRC}) = (F:G)_{SFC}*(P_C + P_{SFC})$,

(4) $P_{DRC} = (F:G)_{SFC}*P_C/(F:G)_{DRC} + (F:G)_{SFC}*P_{SFC}/(F:G)_{DRC} - P_C$, and

(5) $P_{SFC} = (F:G)_{DRC}*P_C/(F:G)_{SFC} + (F:G)_{DRC}*P_{DRC}/(F:G)_{SFC} - P_{C.}$

Where, $(F:G)_i$ is the feed to gain ratio for either SFC or DRC, P_c is the price of corn per pound, P_{DRC} and P_{SFC} are the costs of processing DRC and SFC per pound, respectively. Manipulations of Equation (3) produces (4) and (5), the indifference cost level of each alternative processing method, SFC and DRC, with respect to animal performance, processing cost of the alternative method, and the price of corn. The results of solving for P_{DRC} and P_{SFC} provide the breakeven cost per pound of the respective processing form, given expected feed to gain ratios, and the price of corn.

[8] If the feedlot does not own the cattle, there may be incentive to continue to flake even when dry rolling may be more cost effective. The reason for this is that steam flaking increases the moisture content of the corn, therefore creating an inventory gain that can become a substantial source of revenue over time.

Results

Data collected to evaluate factors affecting the cost of steam flaking contain similar elements as previous studies (Bull and Schake (1980); Cooper et al. (2001); and Macken, Erickson and Klopfenstein ((2006)), and are compared in Table 3.4. The estimates from this work are referred to as "current results" in the table. The timing of each of the studies is important to keep in perspective, as some of the studies were completed more than twenty years ago when costs of elements such as natural gas were substantially different. The costs across some factors may appear similar, but evaluations should be considered cautiously as discount rates, and technological advancements have not occurred evenly across all input costs. The consumption of utilities can be compared keeping in mind that technology likely has changed over time.

The estimated electrical usage (kwh/ton) is 25.85 and 23.13, respectively, for the six-and eighteen-month time periods. Estimates of the current work include usage of either the entire feedlot or the feed mill, so the actual consumption by steam flaking activities with respect to electrical use is likely lower than the estimates. The previous studies show an average of 24.67 kwh/ton, suggesting that previous estimates are likely to have also overestimated electrical consumption per ton. A detailed and summarized breakdown of the main SFC cost components is reported in Table 3.4. The six month estimated usage of natural gas is 0.46 mcf/ton, and 0.43 over the eighteen month period. Natural gas estimates from previous studies show an average consumption 0.96 mcf/ton. However, it is important to analyze these estimates with respect to price levels of natural gas, if natural gas is $2.00/mcf, the cost range would be substantially different if it were $10.00/mcf. The consumption estimates for this study are about half of the usage level that previous studies assume; this may be attributable to technological innovation, especially as price has risen over time. Labor costs, which again are not adjusted for inflation, show the trend of declining as feedyard size increases. This is expected and likely associated with economies of scale. Results of this work support the thoughts of McEllhiney (1986) and Cooper et al. (2001), the main contributing factors to the cost of steam flaking are the consumption electricity and natural gas.

Table 3.4 Comparison Current Results to Previous Studies' Estimates for Factors of Steam Flaking Costs ($/ton) on a Dry Matter Basis.

	Electricity		Natural Gas					
Study	**Cost ($/ton)**	**Usage (kwh/ton)**	**Cost ($/ton)**	**Usage (mcf /ton)**	**Deprec-iation ($/ton)**	**Maintan-ence ($/ton)**	**Labor ($/ton)**	**Total Cost ($/ton)**
Bull and Schake (1980)[a]	1.93	38.88	2.89	1.44	2.05	1.16	1.40	9.79
Bull and Schake (1980)[b]	1.23	24.60	2.14	1.06	1.49	0.83	0.35	6.37
McEllhiney (1986)	1.06	17.70	1.80	0.49	0.91	0.94	0.63	6.23
Brown et al. (2000)	2.25	27.70	2.18	0.91	N/A	N/A	N/A	4.43
Cooper et al. (2001)[a,e]	1.13	22.38	6.19	1.38	1.09	N/A	N/A	8.95
Cooper et al. (2001)[b,e]	1.13	22.38	6.19	1.38	0.78	N/A	N/A	8.48
Macken, Erickson, and Klopfenstein (2006)[a,e]	1.46	26.08	2.52	0.50	2.21	0.75	1.61	8.68
Macken, Erickson, and Klopfenstein (2006)[b,e]	0.99	17.65	2.52	0.50	0.73	0.75	0.62	5.65
Average	1.40	24.67	3.30	0.96	1.32	0.89	0.92	7.32
Minimum	0.99	17.65	1.80	0.49	0.73	0.75	0.35	4.43
Maximum	2.25	38.88	6.19	1.44	2.21	1.16	1.61	9.79
Current Results[c]	**1.50**	**25.85**	**3.93**	**0.46**	**0.66**	**0.76**	**0.94**	**8.25**
Current Results[d]	**1.56**	**23.13**	**3.33**	**0.43**	**0.66**	**0.68**	**1.05**	**7.70**

Note: Estimates reported on an "as fed" basis were converted to a dry-matter basis assuming 20% moisture for steam flaked corn

N/A- Factor was not estimated

[a] - Estimates for a 5,000 head capacity feedlot

[b] - Estimates for a 20,000 head capacity feedlot

[c] - Estimates are an average of 23 feedlots over a 6 month time period, with an average head capacity of 39,000

[d] - Estimates are an average of 17 feedlots over an 18 month time period, with an average head capacity of 32,000

[e] - Study includes other costs, so rows may not horizontally sum to total cost column

The benchmark analysis revealed several interesting points. First, there does not appear to be a strong relationship between average monthly variable cost of steam flaking and level of monthly production across firms. The trend-line in Figure 3.9 demonstrates that there may be slightly negative slope, though the r-squared suggests that the relationship is minimal. The data points in the Figure 3.9 are the average production and variable costs over six months for the 23 feedyards. The previous studies do not effectively allow for economies of scale to be evaluated because they assume that the variable costs are constant for each ton of grain produced. Furthermore, the variable costs may have a seasonal component that contributes to the cost of steam flaking, Figure 3.10 shows that the average variable cost of 17 feedyards could be cyclical. The data for this graph are the average variable cost of the 17 feedyards by month from January 2006 through June 2007. The graph shows that variable costs trend down as the year goes from January to October, and then begin to rise noticeably into the new year. However, these results may not be steadfast as each of the analysis covers a short period of time, and potential implications should be considered in that regard.

Figure 3.9 Average Monthly Variable Costs Compared to Average Monthly Production for 23 Kansas Feedyards, January 2007 – June 2007.

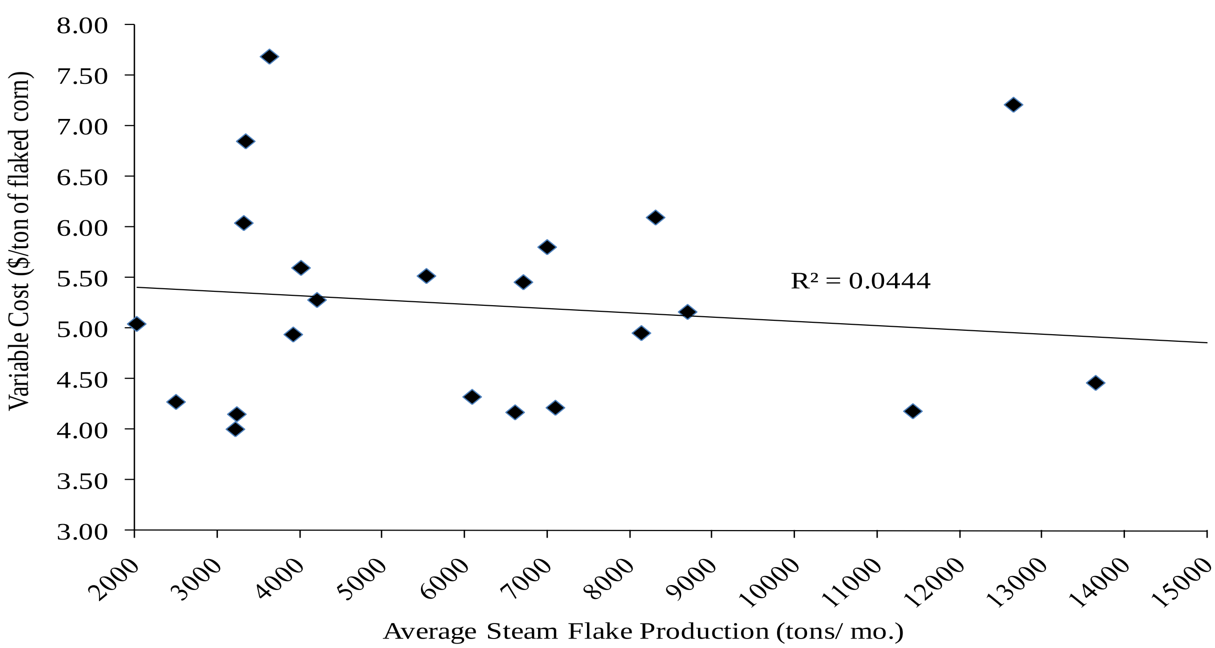
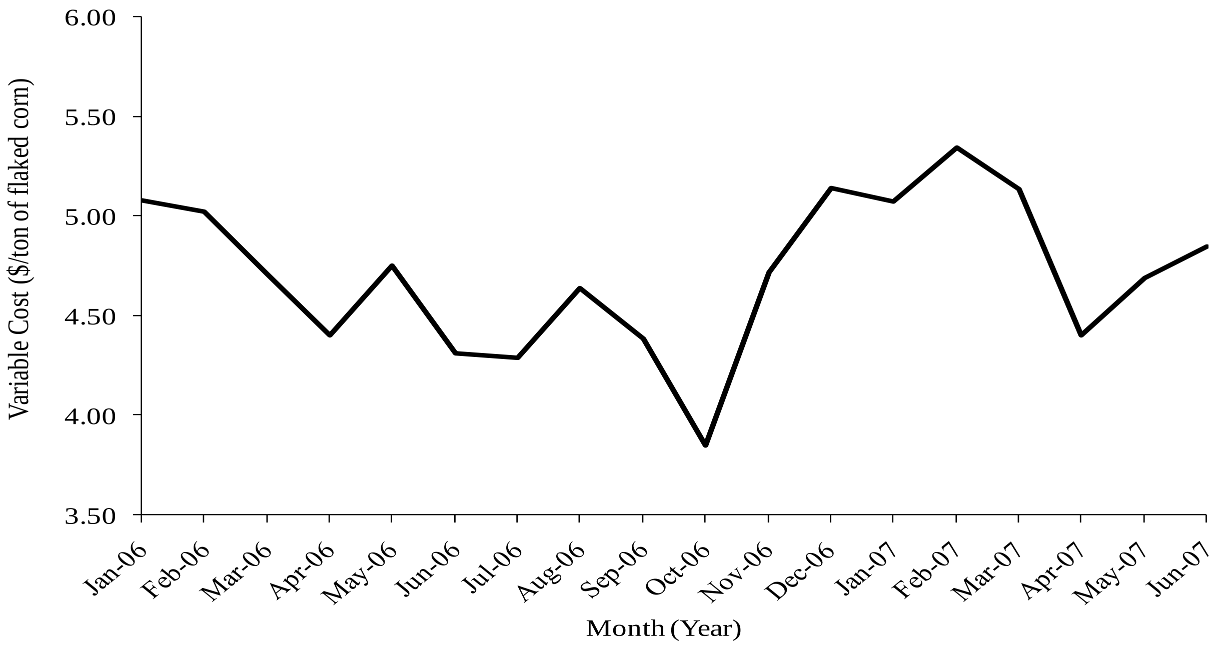


Figure 3.10 Average Monthly Variable Costs for 17 Kansas Feedlots, January 2006 - June 2007.



Time series analysis was limited because the data cover a relatively short period of time, therefore it is difficult to accurately capture variability over time. However, the large number of feedlots providing monthly data allowed for efficiency evaluations through cross-sectional analysis. Therefore, the modeling of SFC cost components was setup to evaluate and quantify the costs across feedyards rather than over time. Table 3.5 exhibits the coefficient estimates of (1) with 230 observations; the model was able to account for nearly 75% of the variability in natural gas consumption[9]. The monthly production variables are relative to June, as it was the relative base. The coefficient estimates for the first six months of the year suggest that they are months were natural gas consumption per ton is expected to be greater than that of June. The summer and fall months (July through October) are not statistically different from June. Though in November and December the consumption per ton is again expected to be increase relative to June. Moreover, most of the monthly production variables were statistically significant at the 1% level, and the magnitudes of the estimates tend to be higher in colder months (e.g. November, December, and February). For example, each ton of corn produced in February uses 0.0824 mcf/ton more than the if it was produced in June. With a difference of nearly 0.08 mcf,

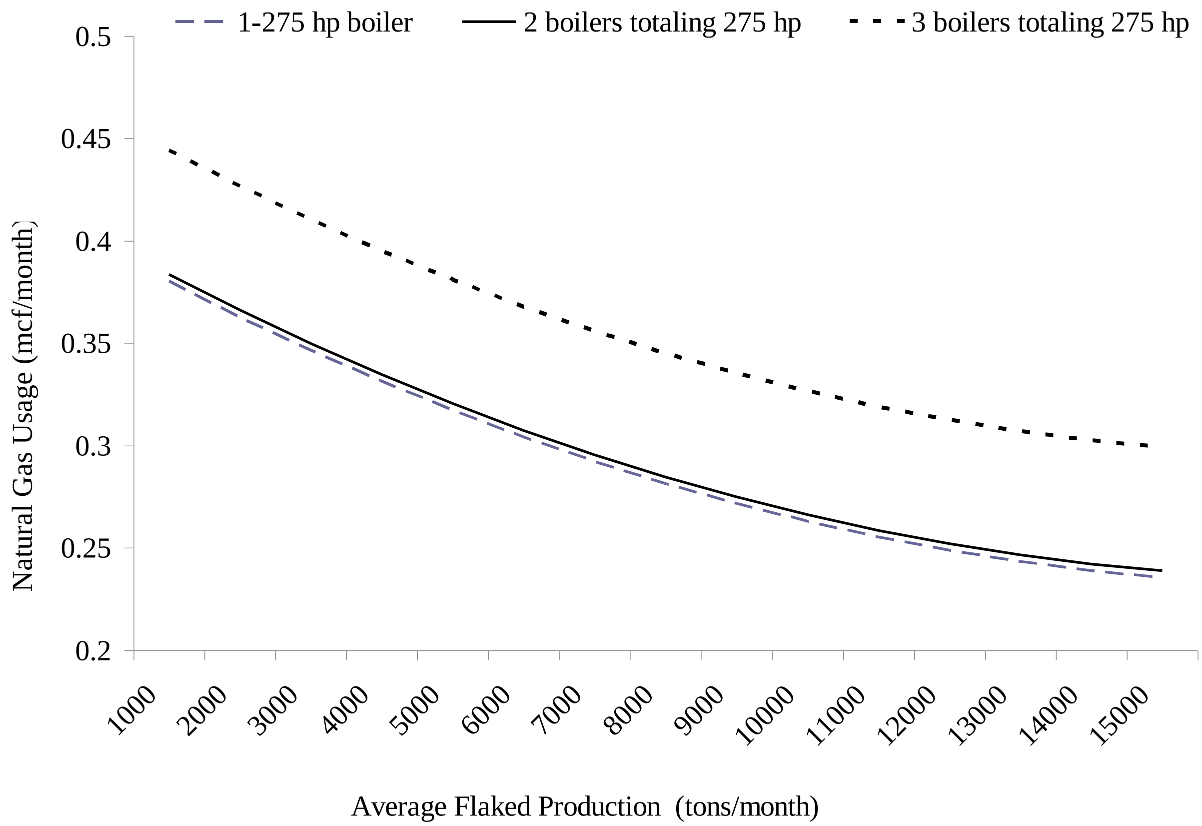
[9] Models 1 and 2 were also run on a monthly basis and the coefficients are reported in Appendix A.

this suggests that for every 1,000 tons produced in February it takes about 80 mcf more than the same level produced in June. Again, considering the price of natural gas, and the level of production, the weather characteristics (most likely temperature) could lead to substantial differences in natural gas expenses. The relationship between total horsepower of the boilers and the number of boilers is negative and statistically significant at the 5% level. However tdhe squared version of this interaction variable is positive, this non-linear effect is demonstrated in Figure 3.11. In this figure, the average total boiler horsepower is held at the average to compare the impact of using two, or three smaller boilers as opposed to a single larger boiler at different levels of average monthly flaked ton production. There does not appear to be a large differentiation between a single and two boilers, though the production capacity of a single boiler limits the relevant range of the graph to less than 10,000 tons per month. The coefficient estimate on the flake density variable implies that as corn is processed less, the consumption of natural gas decreases. This result seems logical because it takes more energy when the corn is processed to a greater extent.

Table 3.5 Coefficient Estimates of Factors Influencing Natural Gas Consumption of Steam Flaking Systems.

Natural Gas Usage (mcf/mo)		
Independent Variable	Estimate	P-Value
Intercept	1.1731	0.0000
January	0.0761	0.0000
February	0.0824	0.0000
March	0.0469	0.0028
April	0.0436	0.0058
May	0.0377	0.0180
July	0.0176	0.3366
August	0.0012	0.9487
September	0.0122	0.5151
October	0.0251	0.1820
November	0.0495	0.0052
December	0.0644	0.0003
Production	-1.90 E -5	0.0000
$(\text{Production})^2$	5.42 E -10	0.0228
total hp*number	-0.0003	0.0000
$(\text{total hp*number})^2$	3.78 E -7	0.0000
Flake density	-0.0244	0.0000
Surfactant	-0.0617	0.0011
N=230	Adj. R^2 =0.74	RMSE= 0.0528

Figure 3.11 Estimated Monthly Natural Gas Usage for 1, 2, or 3 Boilers Totaling 275 Horsepower.

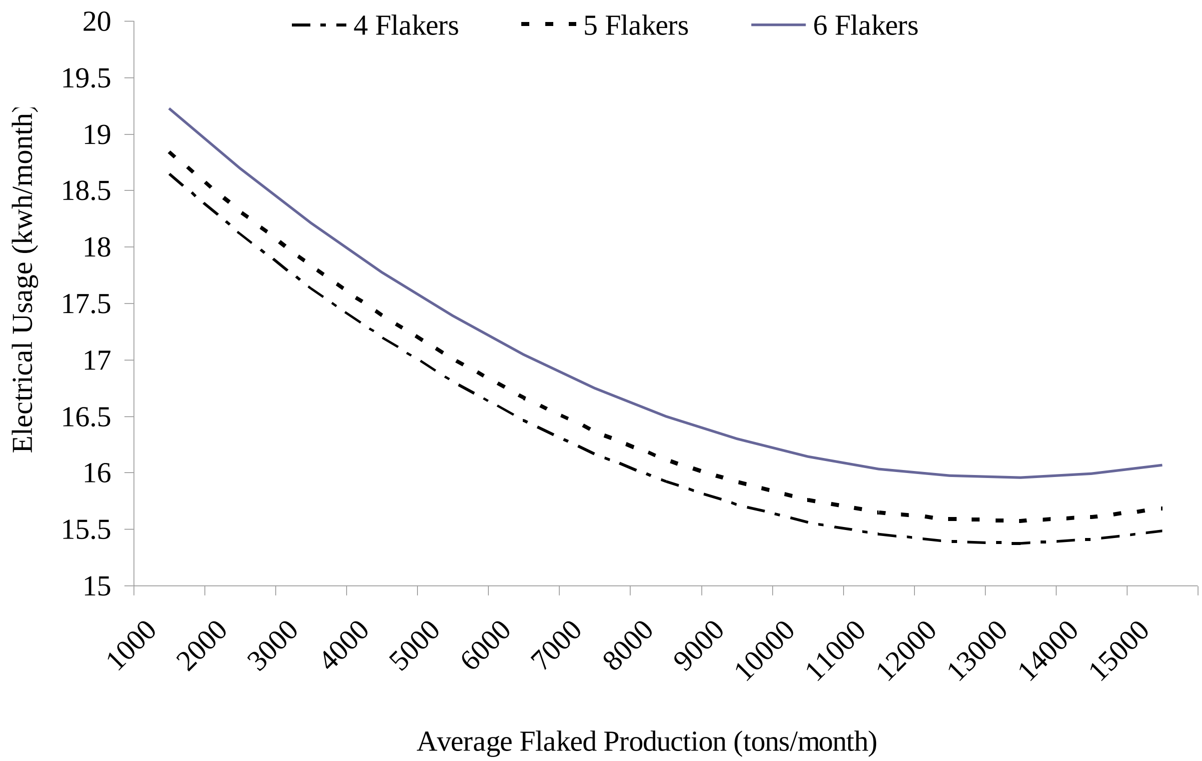


Results of estimating Equation (2) are reported in Table 3.6. The number of observations increase in this model relative to that reported in table 3.7 (236 to 278). This is because some of the feedlots had agreements with natural gas supplying firms in which they were not charged for their consumption and thus were not part of the analyses in Table 3.5. The electrical consumption is not apparently driven by the same factors as natural gas. The model only accounted for 23% of the variability in electrical use, and the monthly production variables are not statistically significant. This may be due to the fact that the relationship of production levels and weather temperature do not have a measurable role in the utilization of electricity. The model does reveal some interesting management practices. Feedlots that start their flakers sequentially, use about 1.36 kilowatt hours per ton less electricity as opposed to feedlots that start the flakers all at once. Lastly, as expected, if the entire feedlot is on the electric bill, there will be more electricity used per ton flaked. Figure 3.12 shows the non-linear affects associated with the number of steam flakers. Here the total horsepower of the flakers is held constant at 240 total horsepower, and average monthly production is varied from 1,000 to 15,000 tons per month. The graph shows that having fewer flakers (4) is more efficient than using a larger number of flakers (6).

Table 3.6 Coefficient Estimates of Factors Influencing Electrical Consumption of Steam Flaking Systems.

Electricity Usage (kwh/mo)		
Independent Variable	Estimate	P-Value
Intercept	35.8100	0.0012
January	-0.8536	0.5445
February	-0.4246	0.7610
March	-2.4326	0.0801
April	-1.9483	0.1711
May	-2.1801	0.1223
July	-0.9165	0.5813
August	-2.0404	0.2285
September	-2.2415	0.1761
October	-2.6632	0.1082
November	-1.7256	0.2710
December	-0.9122	0.5602
Production	-0.0006	0.2043
$(\text{Production})^2$	2.34 E -8	0.3897
total hp*number	-0.0019	0.5179
$(\text{total hp*number})^2$	1.62 E -6	0.1325
Stagger	-1.3633	0.0575
Bill	2.9684	0.0000
Flake Density	-0.5290	0.1695
Surfactant	-3.3834	0.0007
N=256	Adj. R^2 =0.23	RMSE= 5.0029

Figure 3.12 Comparison of Estimated Monthly Electrical Usage for 3, 4, or 5 Flakers Totaling 240 Horsepower.



Combining the estimated cost of SFC and DRC, expected animal performance, and current corn price allows for the breakeven costs for SFC and DRC. If assumptions are made that DG are not used[10] the current corn price is $6/bu., the expected animal performance ratios (F:G) of 6.26 and 5.52, and cost of processing at $1.50/ton and $8.00/ton for DRC and SFC respectively, then the breakeven costs can be calculated. Given these assumptions, Equation (4) shows that the feedlot would have to be compensated by approximately $18.28 to use DRC. Alternatively, Equation (5) under the same assumptions shows that a feedlot can economically rationalize steam flaking if the cost is less than about $30.43/ton. This suggests that feedlots that use a steam flaking system should continue to flake as long as the cost does not exceed $30/ton, well above the estimates calculated in this work. However, these results may not hold when DG

[10] This assumption is used so that the performance estimates from previous studies hold true. Though if robust performance estimates are known when DG are included, they could easily be substituted into the equations to calculate the breakeven costs when using DG.

are used, so calculations were also completed assuming the F:G was 6 for both SFC and DRC. These results show that the new breakeven cost is $7.05/ton and $1.70/ton for DRC and SFC, respectively. Therefore, it seems unfeasible to steam flake, and it appears quite attractive to use a dry-rolling system.

Conclusions

The cost of steam flaking is substantially higher than dry rolling, by as little as $4/ton, and as much or more than $6/ton. The largest contributors in terms of cost are natural gas and electrical utilization efficiencies. The cost of steam flaking contains elements prone to cyclical pricing, natural gas, and therefore, may contain some variability in total cost from month to month. The results of this research suggest that management practices, and setup of the steam flaking system have an impact of the consumption of these utilities. Moreover, it appears that feedlots that employ a sequential startup process for the steam flakers are more efficient with regard to electricity consumption. Also, it appears that the use of two boilers is more efficient than three boilers beyond 10,000 tons per month. Thus suggesting that it is more effective to operate smaller boilers, as long they have the capacity to maintain flaked ton production rate.

Should the steam flaker be shutdown? The answer to that question is that it depends on relative performance with respect to production costs. The key component to consider is the relative change of cost of gain, because the costs of increasing animal weights are vital decision elements. Moreover, generally speaking, it is profitable to increase an animal's weight as long as the expected return for that pound is greater than the cost to gain that pound. However, to maintain operation in a highly competitive industry, if the performance difference is accounted for, steam flaking needs to be cost effective. If a firm employing a dry roll system can produce a pound of weight gain for less than a firm using a steam flake system, relative to performance differences, the dry rolling firm holds the competitive advantage. As shown in the results section, this scenario may certainly be the case when considering the increased inclusion of DG.

DG have been shown to negate efficiency improvements enabled by steam flaking. If this is the case, cattle feeding states that are predominately populated with dry roll systems have a significant advantage to steam flaking. The advantages come in two main forms, the first is that the cost level is lower, therefore the decreasing the costs of production. Secondly, because feedlots that typically have dry roll systems are closer to the DG source, they will be more likely able to use WDG. Therefore, if DG negates the efficiency of weight gain advantage associated with steam flaking, states with dry rolling systems will become instantly low cost production leaders.

The lack of actual energy consumption with components strictly associated with steam flaking and dry rolling is an area where this research could be greatly improved. Also, with a longer time series data set, efficiencies could be evaluated with regard to occupancy rates and seasonality issues that could impact the variability in the cost of grain processing. Vast arrays of opportunities exist for future research with regard to animal performance and the inclusion of DG. Robust feed to gain ratio estimates when DG are present in the ration are needed to better understand the most effective grain processing method.

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Appendix A - Supplemental Coefficient Estimates for Electrical and Natural Gas Consumption

Table A.1 Coefficient Estimates of Factors Influencing Natural Gas Consumption of Steam Flaking Sytems.

Natural Gas Usage (MCF/mo)		
N=236	Adj. R^2 =0.8906	RMSE= 488.62
Independent Variable	Coefficient Estimate	P-Value
Intercept	5134.9283	0.0000
Jan*C	0.1389	0.0000
Feb*C	0.1733	0.0000
Mar*C	0.1209	0.0000
Apr*C	0.1344	0.0000
May*C	0.1101	0.0000
June*C	0.0841	0.0018
July*C	0.1181	0.0000
Aug*C	0.0899	0.0016
Sept*C	0.1106	0.0000
Oct*C	0.1252	0.0000
Nov*C	0.1482	0.0000
Dec*C	0.1760	0.0000
Wheat	554.0410	0.0296
Prod*thp	0.0007	0.0107
$(Prod*thp)^2$	-1.37 E -10	0.0013
Prod*thp*num	-0.0001	0.1053
$(Prod*thp*num)^2$	4.37 E -11	0.0000
FD	-162.7072	0.0000

Table A.2 Coefficient Estimates of Factors Influencing Electrical Consumption of Steam Flaking Sytems.

Electricity Usage (kwh/mo)		
N=278	Adj. R^2 =0.8024	RMSE= 30869
Independent Variable	Coefficient Estimate	P-Value
Intercept	-3934.2183	0.9456
Jan*C	-0.9187	0.5551
Feb*C	1.7515	0.2631
Mar*C	-1.1066	0.4579
Apr*C	0.7434	0.6285
May*C	-0.4235	0.7793
June*C	1.3833	0.3841
July*C	1.3878	0.4327
Aug*C	-1.1809	0.4991
Sept*C	0.4508	0.7858
Oct*C	0.0669	0.9669
Nov*C	1.0472	0.5157
Dec*C	0.7396	0.6498
Wheat	167772.0	0.3100
Prod*thp	0.0622	0.0000
$(Prod*thp)^2$	-6.69 E -9	0.0000
Prod*thp*num	-0.0049	0.0373
$(Prod*thp*num)^2$	2.64 E -10	0.0000
Stagger	-13321.0	0.0024
Bill	27689.0	0.0000
FD	897.3236	0.6668

Appendix B - Sample Steam Flaking Benchmark Reports for Two Feedlots, "x" and "y"

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Steam Flaking Benchmark Cost Study
- Confidential Individual Feedlot Report -

Thank you for your participation in our study examining the costs of steam flaking corn. It was a pleasure to work with you, and we look forward to continuing our partnership. Our intention is to provide useful cost information for your enterprise, as well as the opportunity for comparisons with other feeding operations that participated in the study. If you have any further questions or comments please do not hesitate to contact us.

This report summarizes cost analysis and comparisons for 23 Kansas Feedyards that participated in our study. Data were collected during the summer of 2007 from feedyards ranging in size from 5,000 to more than 70,000 head one time feeding capacity. In our analysis, we included natural gas, electricity, maintenance /repair, and surfactant costs, referred to as variable cost in the analysis. Also included are investment /depreciation and labor costs, these are noted as fixed costs and when combined with variable costs form the total cost per ton flaked estimate. Labor in dollars per ton and is handled as a fixed cost because it was calculated using annual cost of labor and average annual tons of flake production. In regards to depreciation costs, we found it very difficult to be consistent in the collection of investment data, and therefore we obtained estimates of investing in a steam flake production system today. Estimates were obtained from a prominent firm in the mill industry for four sizes of yards; 15,000, 30,000, 50,000, and 70,000 head capacities. The investment cost for the size most similar to yours was used to calculate your depreciation.

In interpreting results it is important to note that there are a variety of feed mill structures and methods to flake corn. For example, some yards use a single large flaker whereas, others use multiple smaller flakers. Similarly, some yards use one large boiler, while others use two smaller boilers. Also, some of the firms have utility bills that include the entire yard, while others have the mill separated out, therefore the analysis of your feedyard should be evaluated with regard to this issue.

With the circumstances of your natural gas cost and usage levels, we have estimated your usage and cost to provide information illustrating the cost of flaking if you were paying for natural gas.

For your yard we particularly note some highlights of things where you appear to be operating your flaking process at costs lower than others and higher than others.

Your yard appears worse than average for:
1. Electrical usage (kwh) per ton
2. Electricity cost per ton
3. Maintenance cost per ton

Feedlot "x" ranks 12th in average variable cost of flaking out of 17[11] feedyards during January 2006 thru June 2007. For January 2007 thru June 2007, your yard is 19th out of 23.

[11] Due to fiscal year ends and data accessibility issues, the time period of data collected is either in 6 or 18 month intervals.

Figure 1 shows the calculated variable cost (electricity + natural gas + maintenance + surfactant) per ton of corn steam flaked for your yard relative to the average of all feedyards in the study over the January 2006 thru June 2007 period. In January 2007costs are quite high, this is because the production of flaked tons was about two thirds less than your normal monthly production, and therefore the utilization of your system was noticeably below its capacity.

Figure 1

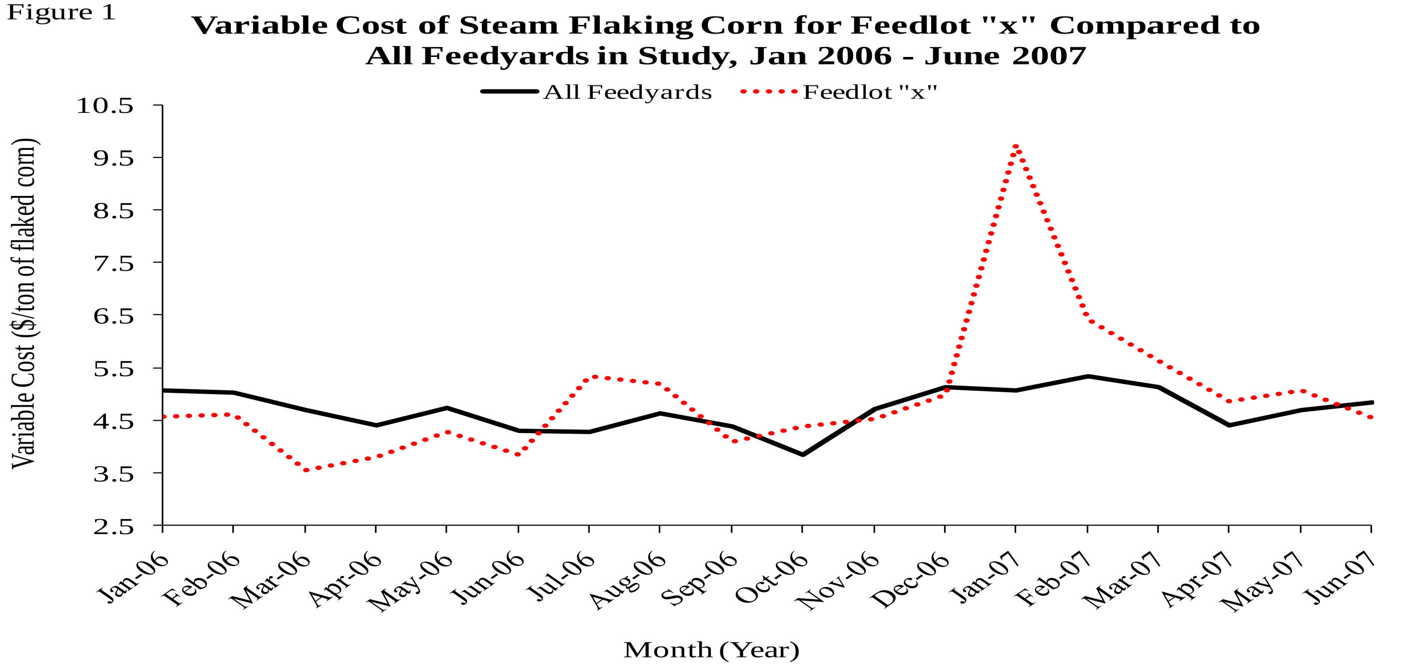
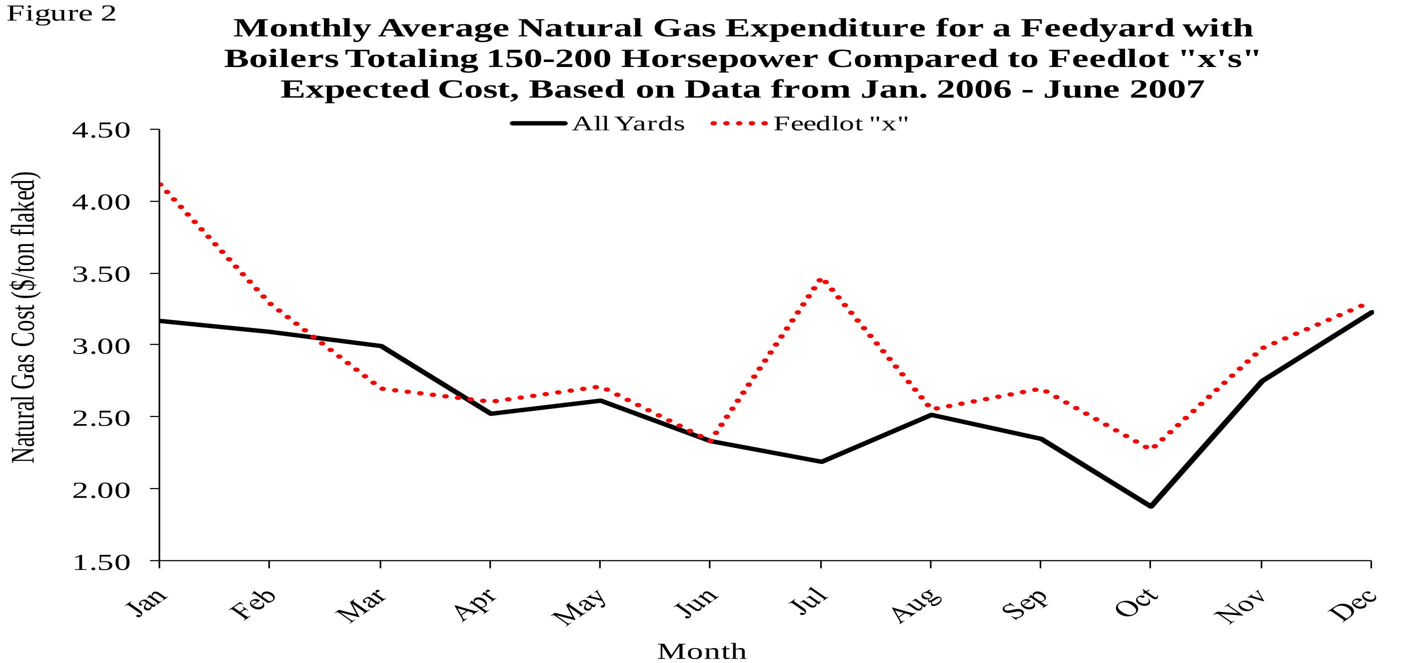


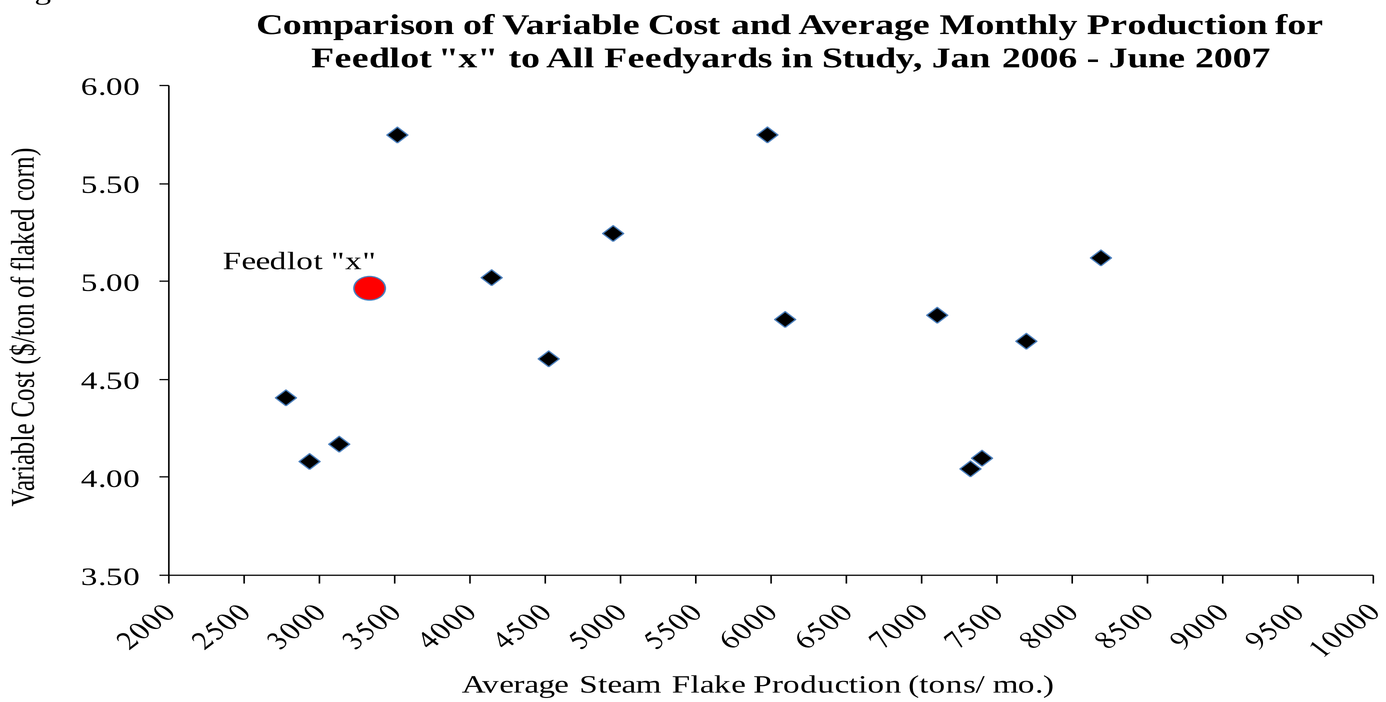
Figure 2 demonstrates that a seasonal component exists for natural gas expenditures on a per ton basis. Your costs for natural gas have been estimated based on your mill characteristics and production to illustrate our expectation of your costs. Feedlot "x" demonstrates an anticipated average natural gas cost per ton that is generally above the average of the yards in the study. The peak in July is also attributable to low flaked ton production level.

Figure 2



In the diagram below, the distribution of variable cost per ton can be seen as average monthly production varies. There does not appear to be a strong correlation between average monthly production and variable cost per ton of flake corn.

Figure 3



In Figure 4, the components encompassed in the variable cost as well as feedlot characteristics are indexed. The average of all feedlots participating is represented by the solid line at the value of one. The values in red represent areas where your costs appear to be above average, and similarly categories in black identify areas where your costs are below the average. For example, your electric cost per ton is above average by a small margin.

Figure 4

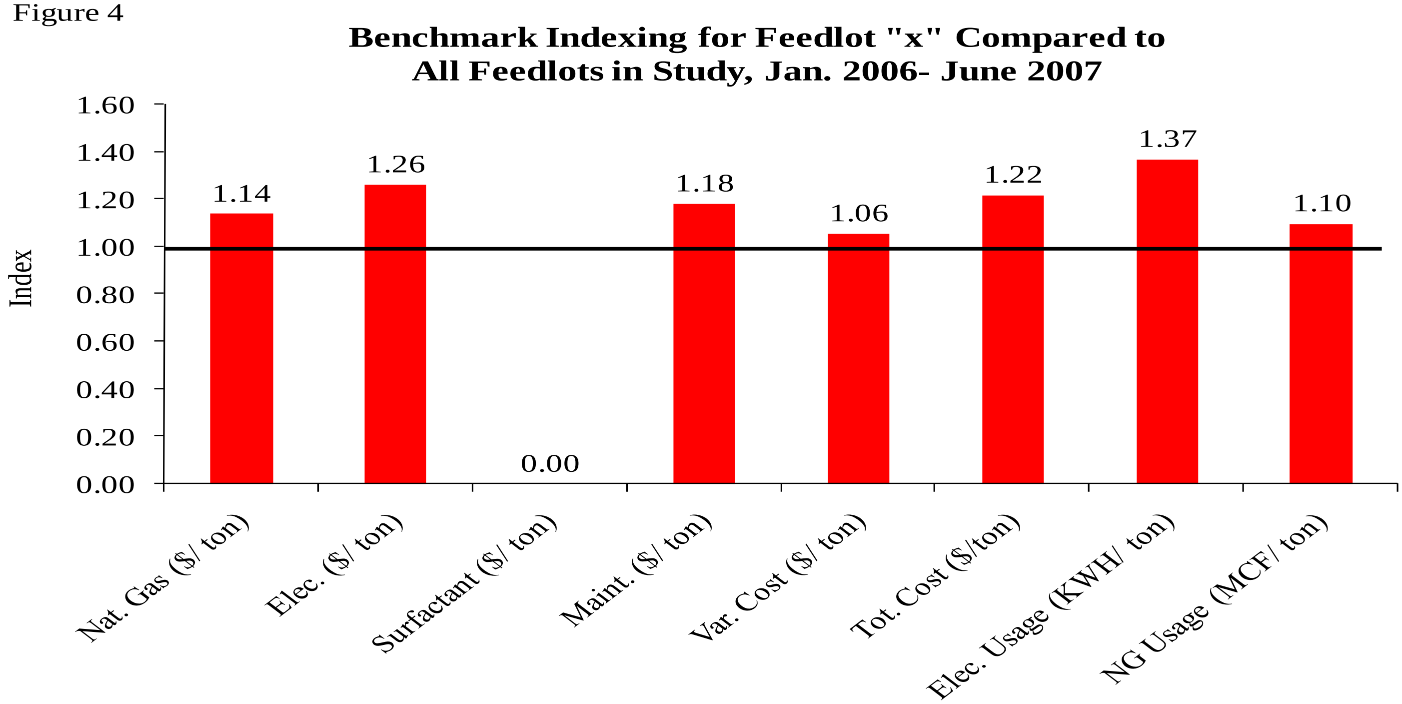


Table 1. Steam Flaking Benchmark Comparisons Across Feedyards

Factor	Feedlot "x"	All Yard-Average	Maximum	Minimum
Natural Gas ($/ton flaked)	3.01	2.64	3.06	2.16
Electricity ($/ton flaked)	1.33	1.05	1.47	0.48
Surfactant ($/ton flaked)	0.00	0.46	1.24	0.00
Maintenance ($/ton flaked)	0.63	0.54	0.89	0.24
Variable Cost ($/ton flaked)	4.97	4.71	5.75	4.02
Labor Cost ($/ton flaked)	1.25	0.75	1.60	0.28
Depreciation Cost ($/ton flaked)	1.17	0.53	1.17	0.20
Fixed Cost ($/ton flaked)	2.42	1.28	2.42	0.48
Total Cost ($/ton flaked)	7.39	6.06	7.78	4.79
Electric Usage --Kilowatt hours (kwh)/ ton flaked	18.32	13.38	19.44	7.36
Natural Gas Usage--Million cubic feet (MCF)/ ton flaked	0.37	0.34	0.42	0.19
Flaking Density (lbs/bu)	28.00	27.42	30.50	24.50
Tons Corn flaked per month	3,335.50	6175.27	N/R	2777.35
Total Horsepower of boilers	150.00	311.96	N/R	125.00
Number of Rollers	2.00	3.61	10	1
Feedlot capacity (Head)	50,000	38,345	60,000+	10,000

* Time period analyzed is from January 2006 thru June 2007

* N/R is not reported to maintain confidentiality

** Surfactant cost per ton is calculated as constant cost per ton as it is an inventoried item, though we recognize that the actual cost per ton is variable based on the characteristics of the corn.

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This report summarizes cost analysis and comparisons for 23 Kansas Feedyards that participated in our study. Data were collected during the summer of 2007 from feedyards ranging in size from 5,000 to more than 70,000 head one time feeding capacity. In our analysis, we included natural gas, electricity, maintenance /repair, and surfactant costs, referred to as variable cost in the analysis. Also included are investment /depreciation and labor costs, these are noted as fixed costs and when combined with variable costs form the total cost per ton flaked estimate. Labor in dollars per ton and is handled as a fixed cost because it was calculated using annual cost of labor and average annual tons of flake production. In regards to depreciation costs, we found it very difficult to be consistent in the collection of investment data, and therefore we obtained estimates of investing in a steam flake production system today. Estimates were obtained from a prominent firm in the mill industry for four sizes of yards; 15,000, 30,000, 50,000, and 70,000 head capacities. The investment cost for the size most similar to yours was used to calculate your depreciation.

In interpreting results it is important to note that there are a variety of feed mill structures and methods to flake corn. For example, some yards use a single large flaker whereas, others use multiple smaller flakers. Similarly, some yards use one large boiler, while others use two smaller boilers. Also, some of the firms have utility bills that include the entire yard, while others have the mill separated out, therefore the analysis of your feedyard should be evaluated with regard to this issue.

For your yard we particularly note some highlights of things where you appear to be operating your flaking process at costs lower than others and higher than others.

Your yard appears to be better than average for:
1. Natural gas cost per ton
2. Electricity cost per ton
3. Electricity usage (kwh) per ton

Feedlot "y" ranks 1st in average variable cost of flaking out of 17[12] feedyards during January 2006 thru June 2007. For January 2007 thru June 2007, your yard is 5th out of 23.

[12] Due to fiscal year ends and data accessibility issues, the time period of data collected is either in 6 or 18 month intervals.

Figure 1 shows the calculated variable cost (electricity + natural gas + maintenance + surfactant) per ton of corn steam flaked for your yard relative to the average of all feedyards in the study over the January 2006 thru June 2007 period. Your corn steam flaking costs generally follow the trend of the composite average, though at a lower level.

Figure 1

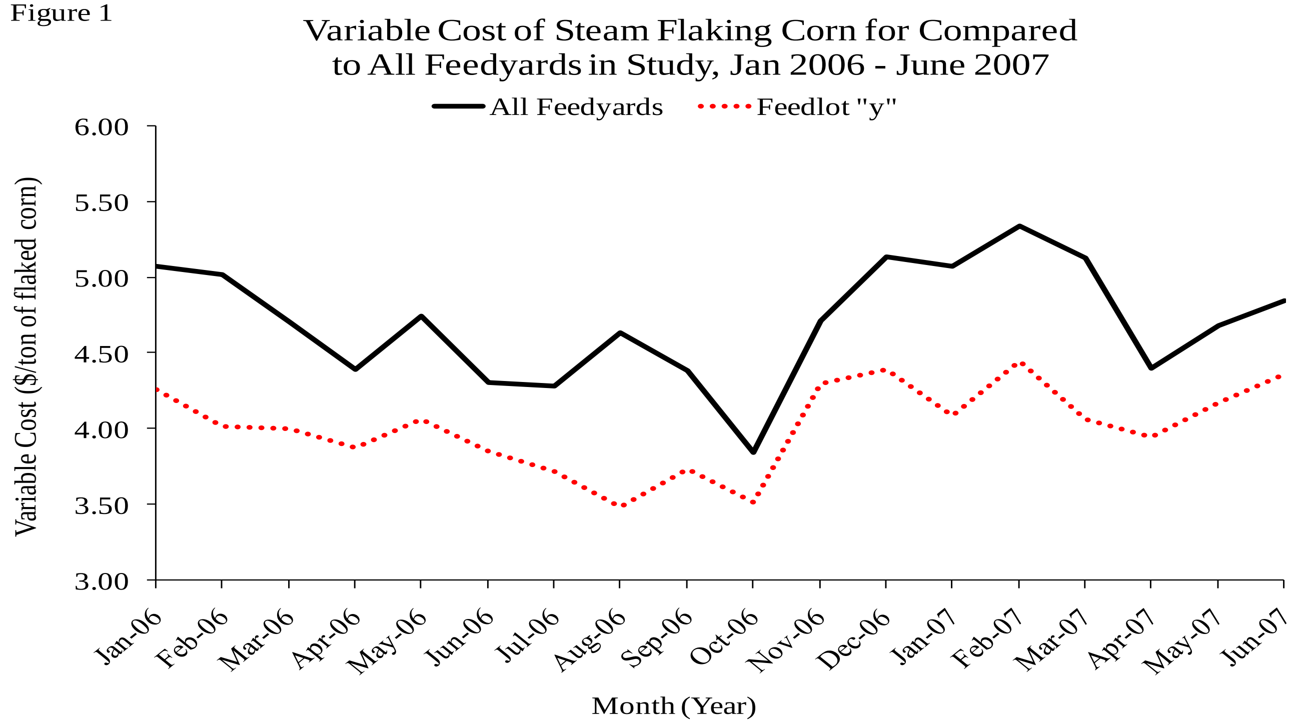
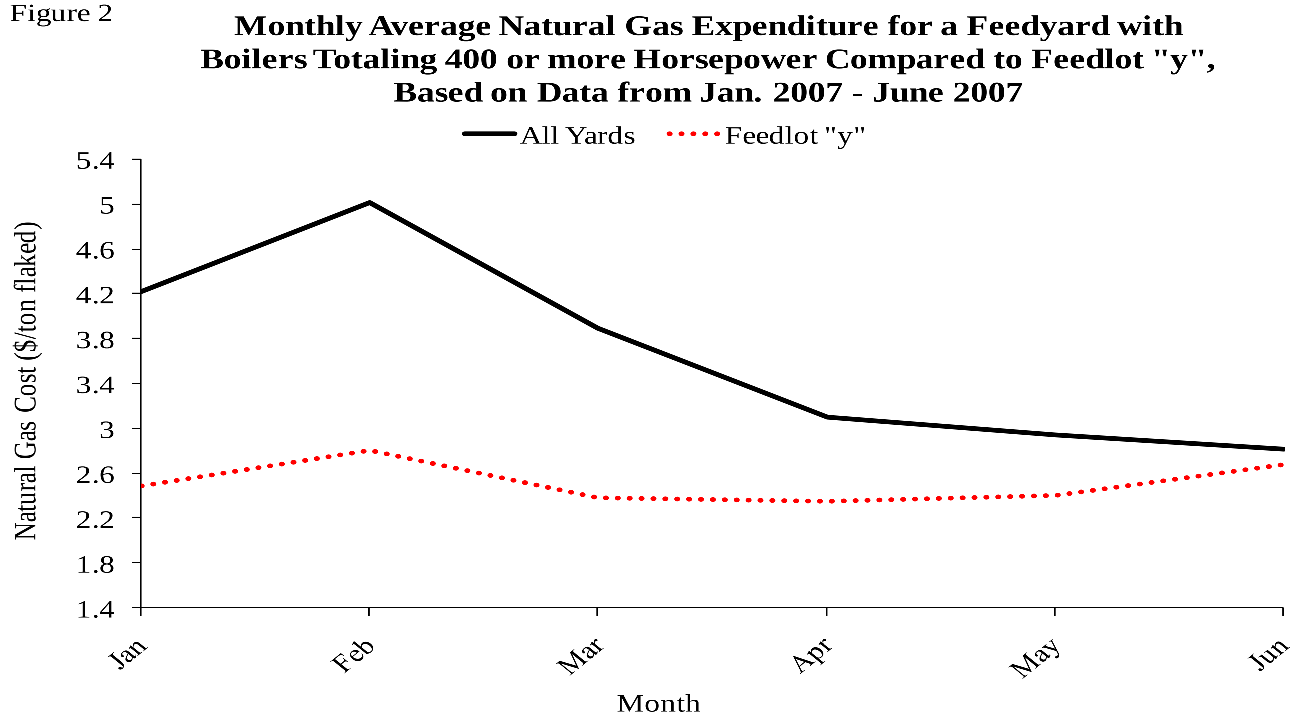


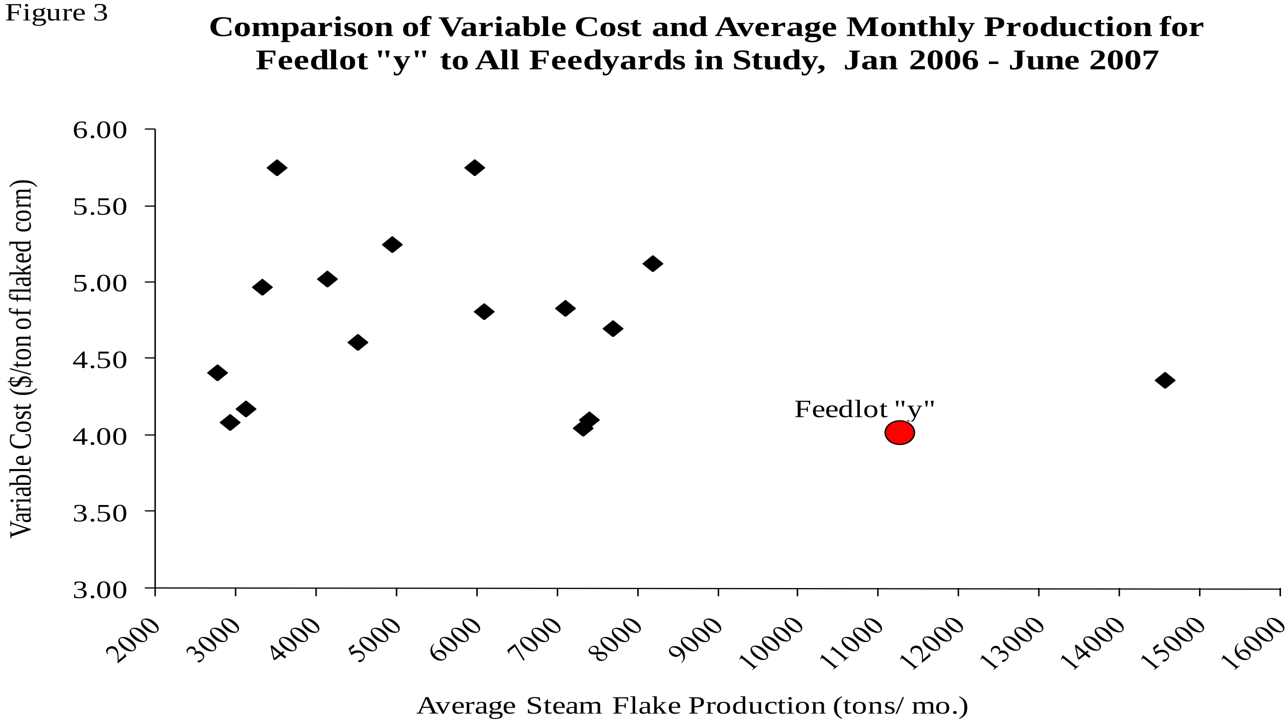
Figure 2 demonstrates that a seasonal component exists for natural gas expenditures on a per ton basis. Feedlot "y" generally demonstrates an average natural gas per ton that follows the average of the other yards in the study, though at a lower cost level.

Figure 2



In the diagram below, the distribution of variable cost per ton can be seen as average monthly production varies. There does not appear to be a strong correlation between average monthly production and variable cost per ton of flake corn.

Figure 3



In Figure 4, the components encompassed in the variable cost as well as feedlot characteristics are indexed. The average of all feedlots participating is represented by the solid line at the value of one. The values in red represent areas where your costs appear to be above average, and similarly categories in black identify areas where your costs are below the average. For example, your natural gas cost per ton is below average by a small margin.

Figure 4

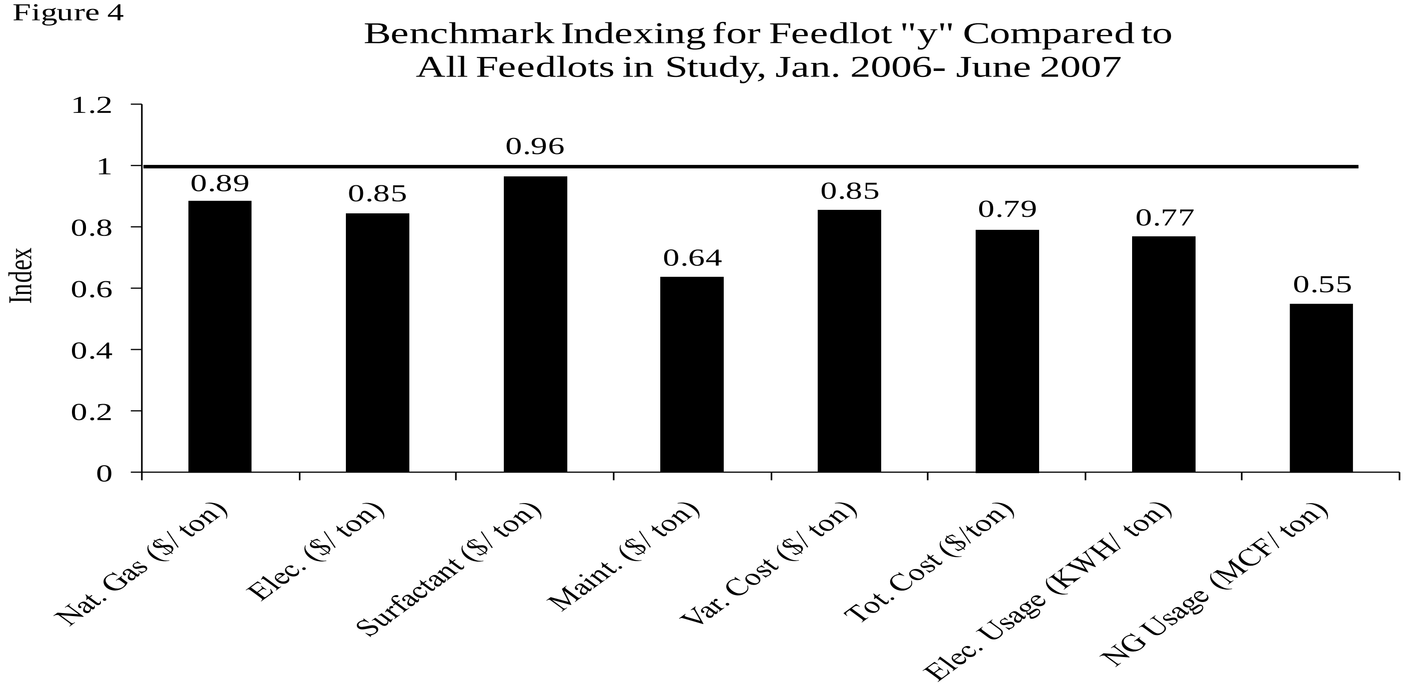


Table 1. Steam Flaking Benchmark Comparisons Across Feedyards

Factor	Feedlot "y"	All Yard-Average	Maximum	Minimum
Natural Gas ($/ton flaked)	2.35	2.64	3.06	2.16
Electricity ($/ton flaked)	0.89	1.05	1.47	0.48
Surfactant ($/ton flaked)	0.44	0.46	1.24	0.00
Maintenance ($/ton flaked)	0.34	0.54	0.89	0.24
Variable Cost ($/ton flaked)	4.02	4.71	5.75	4.02
Labor Cost ($/ton flaked)	0.42	0.75	1.60	0.28
Depreciation Cost ($/ton flaked)	0.35	0.53	1.17	0.20
Fixed Cost ($/ton flaked)	0.77	1.28	2.42	0.48
Total Cost ($/ton flaked)	4.79	6.06	7.78	4.79
Electric Usage --Kilowatt hours (kwh)/ ton flaked	10.26	13.38	19.44	7.36
Natural Gas Usage--Million cubic feet (MCF)/ ton flaked	0.19	0.34	0.42	0.19
Flaking Density (lbs/bu)	30.50	27.42	30.50	24.50
Tons Corn flaked per month	11,276.06	6175.27	N/R	2777.35
Total Horsepower of boilers	400.00	311.96	N/R	125.00
Number of Rollers	2.00	3.61	10	1
Feedlot capacity (Head)	50,000	38,345	60,000+	10,000

* Time period analyzed is from January 2006 thru June 2007

* N/R is not reported to maintain confidentiality

** Surfactant cost per ton is calculated as constant cost per ton as it is an inventoried item, though we recognize that the actual cost per ton is variable based on the characteristics of the corn.