Staff Paper

Modeling the U.S. Domestic Livestock Feed Sector in a Period of Rapidly Expanding By-Product Feed Supplies from Ethanol Production

John N. (Jake) Ferris

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Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

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John N. (Jake) Ferris
Jakemax33@comcast.net

Abstract

Rapidly expanding ethanol production in the U.S. was given further impetus with the passage of the Energy Policy Act of 2005 mandating a minimum production of 7.5 billion gallons of renewable fuels by 2012. The availability of the by-product feeds of ethanol production (corn gluten feed and meal and DDG) has not only become a significant share of the protein feed sector, but also the increase has been and will be extensive. The challenge is how to incorporate these feeds into econometric models of U.S. agriculture and measure their impact on the utilization of other feeds, particularly coarse grain and soybean meal. Another task is to forecast prices on the by-product feeds.

This paper suggests a couple of procedures embracing the entire sector of livestock concentrates, including both protein and energy feeds. The feeds were converted into protein equivalents and energy equivalents and introduced into regression equations predicting (1) the amounts of soybean meal and coarse grain fed and (2) the amount of protein feeds utilized in protein equivalents and the amount of all concentrate feeds utilized in energy equivalents.

In case (2), the amounts of soybean meal and coarse grain fed were derived by deducting the protein and energy equivalents of the other feeds from the totals predicted. This case was the one selected to be incorporated into AGMOD, an econometric model of U.S. agriculture.

To forecast prices on the by-product feeds of ethanol production, synthetic prices for protein and energy were derived from prices on soybean meal and corn. Applying these prices to the ethanol byproduct feeds, values for these feeds were generated. These values were the major explanatory variables associated with the by-product prices supplemented by variables representing the ratios of the utilization of the respective feeds in protein equivalents to the total utilization of protein feeds in protein equivalents.

Prices on corn gluten feed and DDG have been declining relative to their values, with continued downward pressure in prospect for prices on DDG in the next 10 years.

21 pages.

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John N. (Jake) Ferris
Professor Emeritus
Department of Agricultural Economics
Michigan State University

In the past 10 years, ethanol production in the U.S. has quadrupled, doubling between 2001 and 2005 to nearly 4 billion gallons. By 2007, the industry will have added another 2 billion gallons. The "Renewable Fuels Standard" (RFS) in the federal *Energy Policy Act of 2005* mandates a minimum of 7.5 billion gallons of renewable fuels (including biodiesel) by 2012, with provisions for expanding the RFS beyond 2012 in line with gasoline use. Very likely, ethanol production will exceed this guideline by 2012 even with an allowance for biodiesel.

Wet versus Dry Milling

Ethanol has been produced by two major processes, wet milling and dry milling. Traditionally, most of the production has been in wet mills. Around 1990, estimates were that about 293 million bushels of corn were processed into ethanol in wet mills and 56 million bushels of corn were processed into ethanol in dry mills. Also, another 379 million bushels of corn were being processed into high fructose corn syrup (HFCS) in wet mills. Wet mills have the capacity to shift between ethanol and HFCS as economics dictates, so the capacity for producing ethanol around 1990 was predominantly with the wet mills. Other major products of wet milling are glucose/dextrose, starch and corn oil.

Wet mills require large capital investments which achieve both economies to scale and the flexibility in shifting among alternative products. Dry mills are on a smaller scale and benefit from (1) more flexibility in selecting locations and (2) reduced capital outlays. However, they must largely specialize in ethanol production. Many dry mills are farmer cooperatives. Most of the expansion since 1996 has been in dry mill production of ethanol. Even wet millers are planning expansion in dry mill production.

Estimates of the allocation of ethanol production between wet and dry mills are somewhat elusive in that no official data exist. This author estimates that dry mills produced about two-thirds of the ethanol output for the 2005-06 crop year. This share will continue to increase over the next decade.

Feed by-products from wet milling are corn gluten feed and corn gluten meal. A bushel of corn processed into ethanol from the wet milling process generates about 16.15 pounds of corn gluten feed and meal. In this combination, corn gluten feed represents about 84 percent and corn gluten meal about 16 percent. Corn gluten feed has a protein content (as fed) of about 23.6 percent and corn gluten meal has a crude protein content (as fed) of about 43.1 percent (Ensminger and Olentine, 1980). Prices, however, are quoted for 21 percent corn gluten feed and 60 percent corn gluten meal.

The feed by-product from dry milling is distillers' dried grains and solubles (DDG). A bushel of corn processed into ethanol (or other alcohol) in dry mills results in about 18 pounds of DDG. The dried product has a protein content of about 28.1 percent (as fed) (Ensminger and Olentine, 1980). In this paper, the stated conversion coefficients for both the corn gluten feed/meal and DDG were held constant, realizing that efficiencies have likely improved over time.

Corn is the predominant feedstock for ethanol production with very minor amounts of other feedstock involved such as barley, grain sorghum, wheat starch, cheese whey and beverage waste (Renewable Fuels Association, 2006). Table 1 provides a perspective on the ethanol industry as a sector in the food and industrial use of corn, as estimated for the 2005-06 marketing year. The estimates are from the Economic Research Service of the U.S. Department of Agriculture except for the division between wet milling and dry milling fuel ethanol usage, which are the author's.

Table 1.

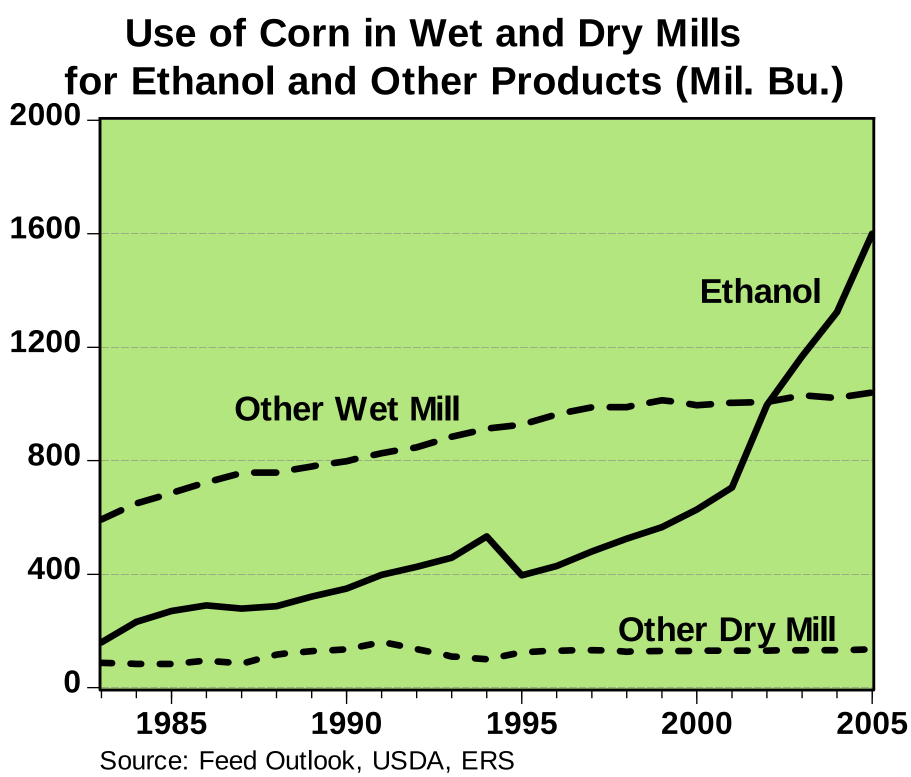
Food and Industrial Use of Corn, 2005-06 Crop Year[1]

	Million bushels
Wet Corn Milling	
Fuel Alcohol (Ethanol)	512[2]
High Fructose Corn Syrup	535
Glucose and Dextrose	225
Starch	280
Dry Corn Milling	
Alcohol	
Fuel (Ethanol)	1088[2]
Beverage and Manufacturing	135
Cereals and Other Products	190
Total	2965

[1]U.S. Department of Agriculture, Economic Research Service, *Feed Outlook*, FDS-06d, May 16, 2006
[2]Estimate by author

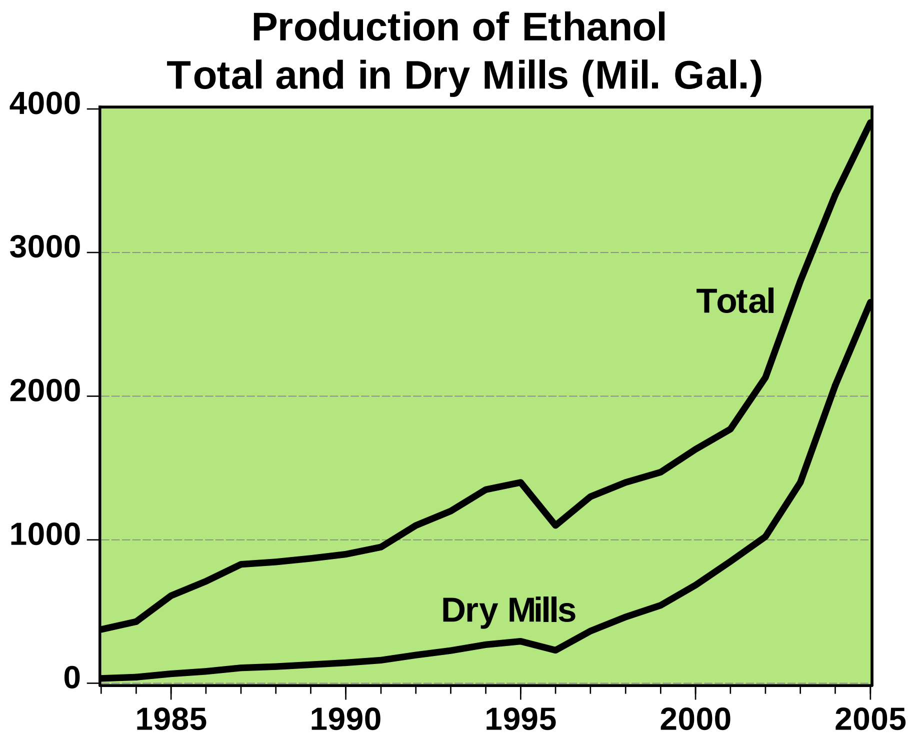
The production of the corn gluten feed and meal by the wet milling industry is derived not only from ethanol production but also from the output of high fructose corn syrup, glucose and dextrose and starch. Similarly, distillers' dried grains are the by-products of both ethanol and beverage operations of the dry milling industry. Figure 1 below traces the amounts of corn going into ethanol in comparison to corn usage for other wet mill and dry mill products. Note that in the 2005-06 crop year, corn processed into ethanol exceeded the amounts going into the combination of other products. In terms of total U.S. corn production, wet and dry mill usage represented a fourth with ethanol accounting for about 14 percent in the 2005-06 crop year. In the 1983-84 crop year, these numbers were 20 and 4 percent, respectively.

Figure 1.



Estimates of total production of ethanol are available from the Renewable Fuels Association (RFA) going back to 1980. Figure 2 presents RFA's calendar year totals and this author's estimates of the production from dry mills since 1983. The expansion was consistent except for a retrenchment in 1995 when corn prices peaked over $3.00 per bushel. As evident, nearly all the increase in ethanol production has been in dry mills. That dry milling will likely continue to increase its share of output can be documented by construction plans of existing operations. Even a wet miller is planning to expand ethanol production in dry mills according to news releases from the Archer Daniels Midland Company with 500 million gallons as a target for 2008 (Archer Daniels Midland, 2005).

Figure 2.

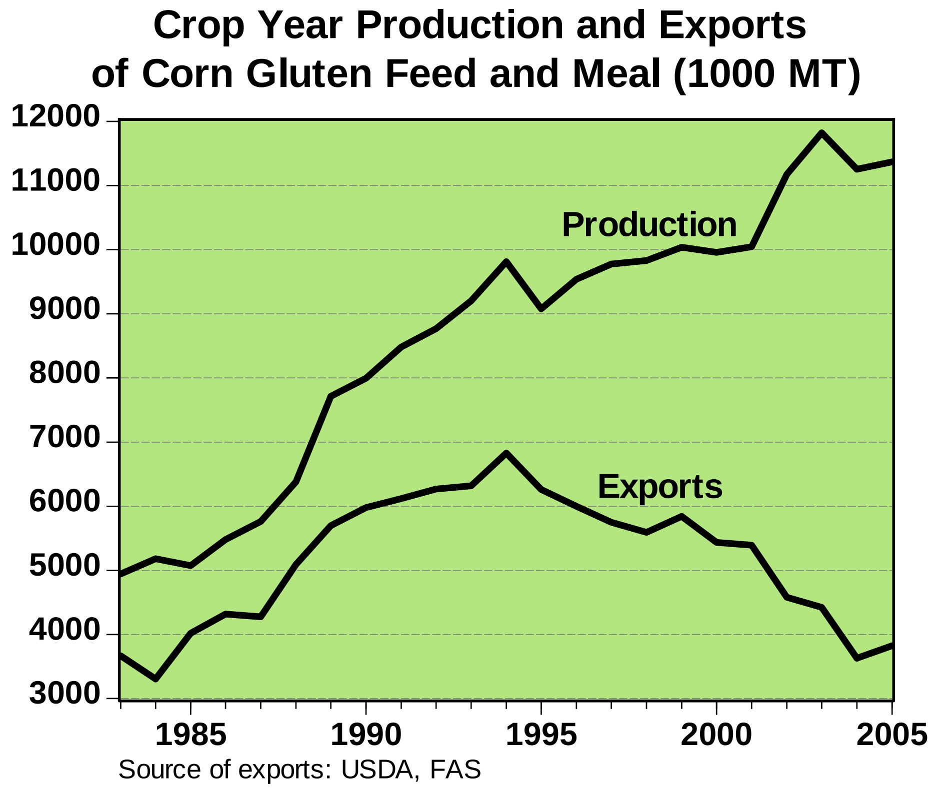


Source for total production: Renewable Fuels Association

While not easily identified in Figure 2, ethanol production from wet mills did increase over the 1983 to 2005 period along with a substantial expansion in the output of high fructose corn syrup. As can be seen in Table 1, the amount of corn going into high fructose corn syrup production is comparable to the amount going into ethanol at wet milling plants. Some leveling off is noted in recent years. The amount of corn going into starch has also trended upward. Corn utilization for glucose and dextrose leveled off after increasing into the early 1990s.

The resultant rapid increase in the production of the by-products of corn gluten feed and meal between 1983 and 1994 was nearly matched by expanded exports which went mostly to the European Union (EU). Production of corn gluten feed and meal continued to increase after a dip in the 1995 crop year, but exports dropped off significantly (Figure 3). This reversal can be attributed to a modification in the Common Agricultural Policy (CAP) and to exchange rates. With declining price supports on grain and weakening of the euro, the high grain prices in the EU dipped closer to the world market. This lessened the price advantage of protein feeds which had been entering the EU market with little restrictions. When the CAP's grain supports were high relative to world prices for both grain and protein feeds, corn gluten feed and meal and other imported protein feeds were fed as a source of energy as well as protein (Hasha, 2002). Also, to be noted is that 1995 was the year GMOs were introduced in the U.S. and denounced in Europe.

Figure 3.[1]



With the widening gap between production and exports of corn gluten feed and meal, the domestic feeding of these by-products increased substantially. But presuming that relatively small quantities of distillers' dried grains are exported, the rapid growth in dry mill ethanol production has now accelerated the utilization of distillers' dried grains in livestock rations to a point likely in excess of the wet mill by-product feeds (Figure 4). Measured in protein equivalents, the two sources have become a significant share of the protein feed market (Figure 5).

[1] The production of corn gluten feed and meal was estimated by adding exports from the USDA's Foreign Agriculture Service to utilization as estimated in the *Feed Outlook* series of the USDA's Economic Research Service for 1983 to 1988. After 1988, production was estimated by multiplying the amount of corn utilized in wet milling by factors related to the conversion of corn to the by-product feeds.

Figure 4.

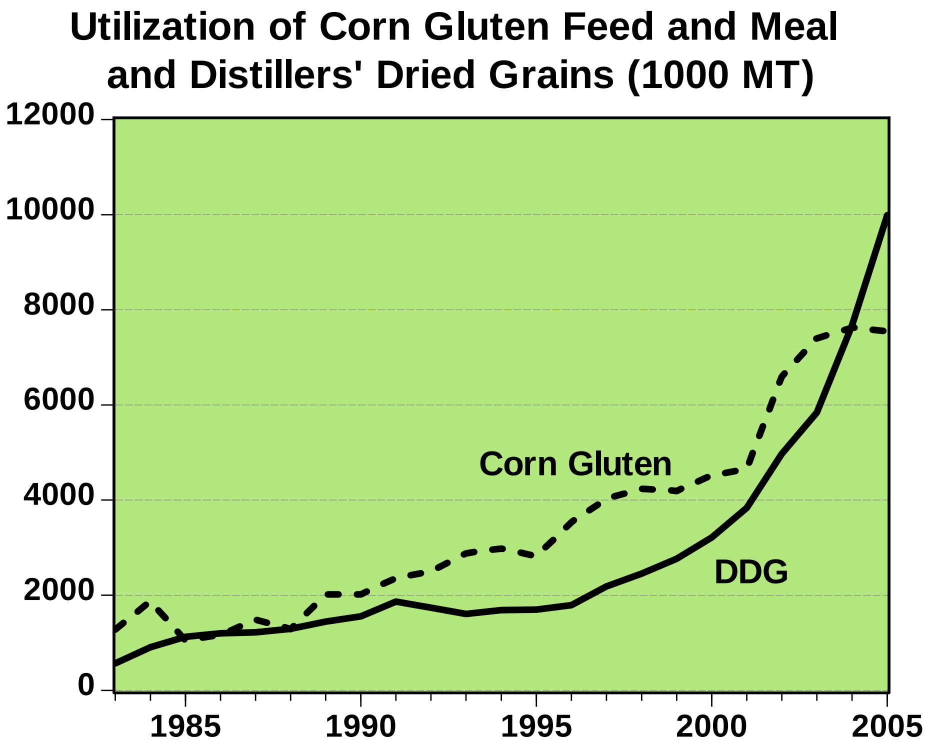
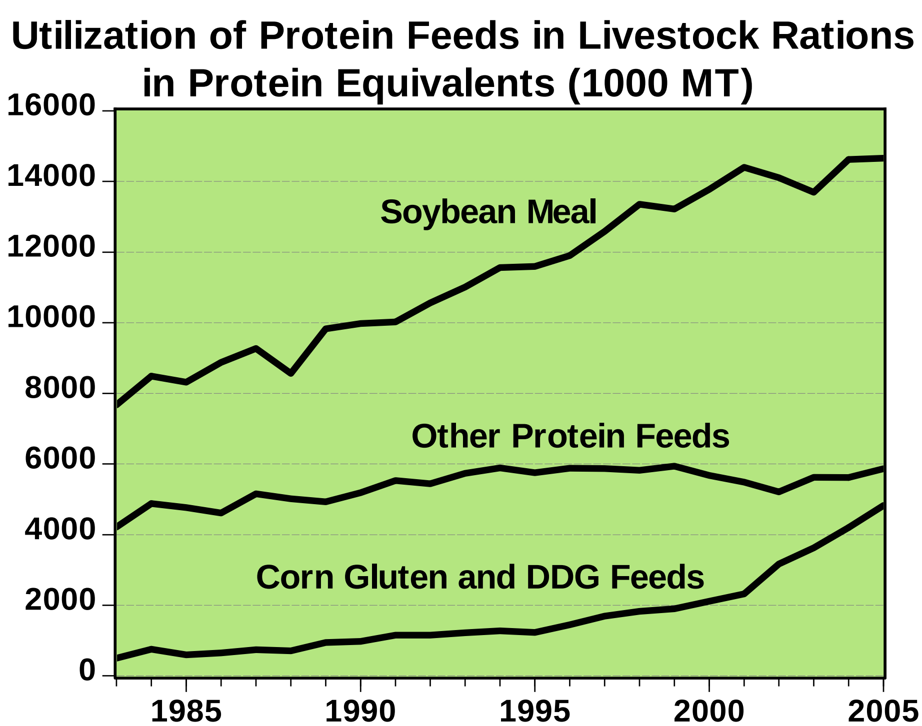


Figure 5.



Incorporating By-Product Feeds into Livestock Sector Models

In the past, forecasting the utilization of coarse grain and soybean meal in livestock rations could be accomplished without much attention to the role of by-product feeds. This was due, not only to their relatively minor importance, but also to the fact that their collective availability changed rather gradually over time. Possibly some type of "time" variable could handle their impact in regression analysis. But now and in the foreseeable future, these sources of protein and energy are significant and likely to increase in major increments.

The challenge is how to integrate the numerous by-product feeds into the analysis. Obviously, some common denominators such as protein content were needed. The other common denominator was some measurement of energy in the respective feeds. To track the utilization of the various by-product feeds over time, the data base of the Economic Research Service (ERS) of the USDA was tapped. In Table A1 in the Appendix is a list of those feeds and notations relative to estimates which are not those of ERS.

The first column in Table A1 displays recent estimates of ERS of the quantity fed (USDA, ERS, *Feed Situation and Outlook Yearbook*, FDS-2005, April 2005). The second column lists the crude protein percents (as fed) from Ensminger and Olentine for each of the feeds. The third column is a calculation for each feed of the energy content (as fed), again based on Ensminger and Olentine.

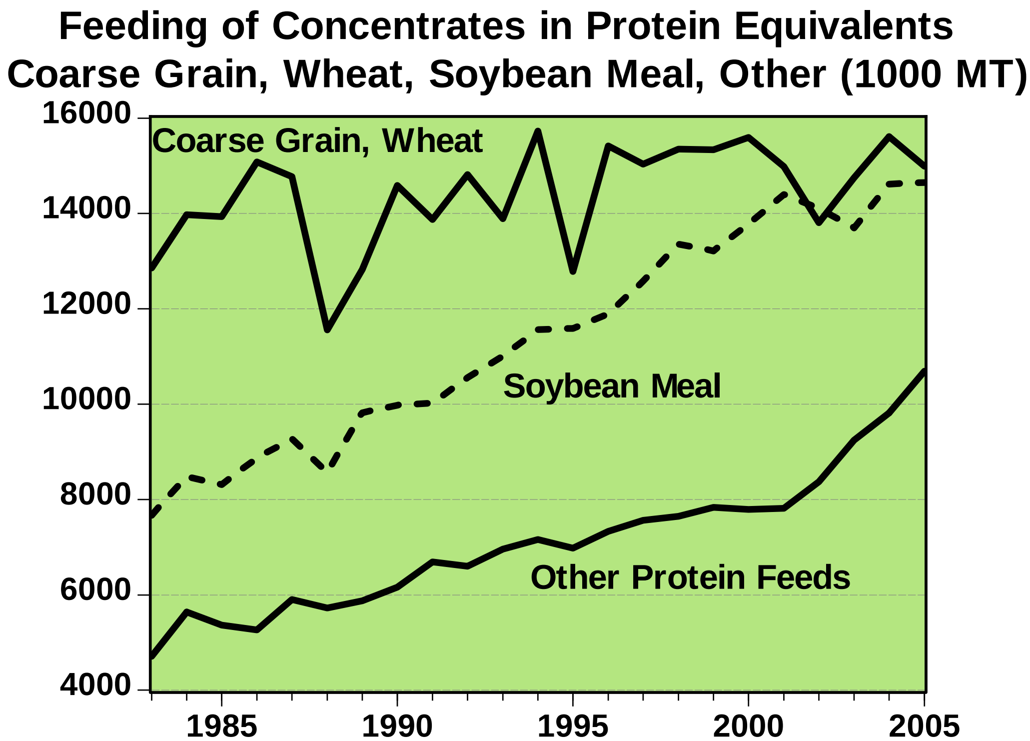
Here is how the energy component was calculated. Ensminger and Olentine report metabolizable energy in terms of million or thousand calories per pound for feeding ruminants, swine and poultry (also horses). Based on ERS estimates of feeding of concentrates in the 2004-05 crop year, 39.1 percent was to ruminants, 26.2 percent to swine and 34.7 percent to poultry. These percentages provided the weights for estimating the energy in calories for each of the feeds, except that distillers' dried grain was restricted to ruminants and beet pulp to ruminants and swine. This is not to indicate that distillers' dried grain is not suitable for swine and poultry but animal nutritionists have set the upper limit at relatively low levels. With research under way these limits will likely be raised.

Since crops such as corn, sorghum, barley and oats, as coarse grains, are considered energy feeds, their competition in domestic livestock feeding is with the energy content of all the other feeds. Similarly, soybean meal, the prominent protein feed, faces competition from all the other feeds relative to their protein content. Therefore, why not evaluate the feeding of coarse grain with some measurement of this competition in energy equivalents. Also, why not measure the feeding of soybean meal with some measurement of the competition in terms of protein equivalents?

For those reasons, two variables were constructed, one for the protein content of all the feeds listed in Table A1 except soybean meal. The other variable was derived from the energy content of all the variables listed in Table A1 except for coarse grain. A view of trends in the feeding of concentrates in terms of protein equivalents is presented in

Figure 6. Note that the feeding of coarse grain and wheat has exhibited little trend while soybean meal utilization has increased almost linearly in the 1983 to 2005 period. The utilization of other protein feeds trended upward with acceleration after the year 2000.

Figure 6.



If all these concentrate feeds were added together, the total would display an upward trend due to the impact of the protein feeds as shown in Figure 7. If soybean meal were deducted from the total, the result would still be an increase over time because of the effect of the utilization of the other protein feeds, also indicated in Figure 7. However, because of the lack of trend in feeding of coarse grain and wheat, the ratio of (1) concentrates fed except for soybean meal to (2) total concentrates fed in protein equivalents declined in the 1983 to 2005 period. This decline is illustrated in Figure 8, which also indicates some reversal after 2000 due to the expansion in by-product feeds of the ethanol industry.

To view trends in the utilization of concentrates in terms of energy equivalents, Figure 9 portrays (1) the total for coarse grains, wheat and the protein feeds and (2) the total less the energy equivalents of the coarse grains. Figure 10 charts the ratio between (2) and (1). Note the fairly consistent increase in the ratio over the 1983 to 2005 period.

Figure 7.

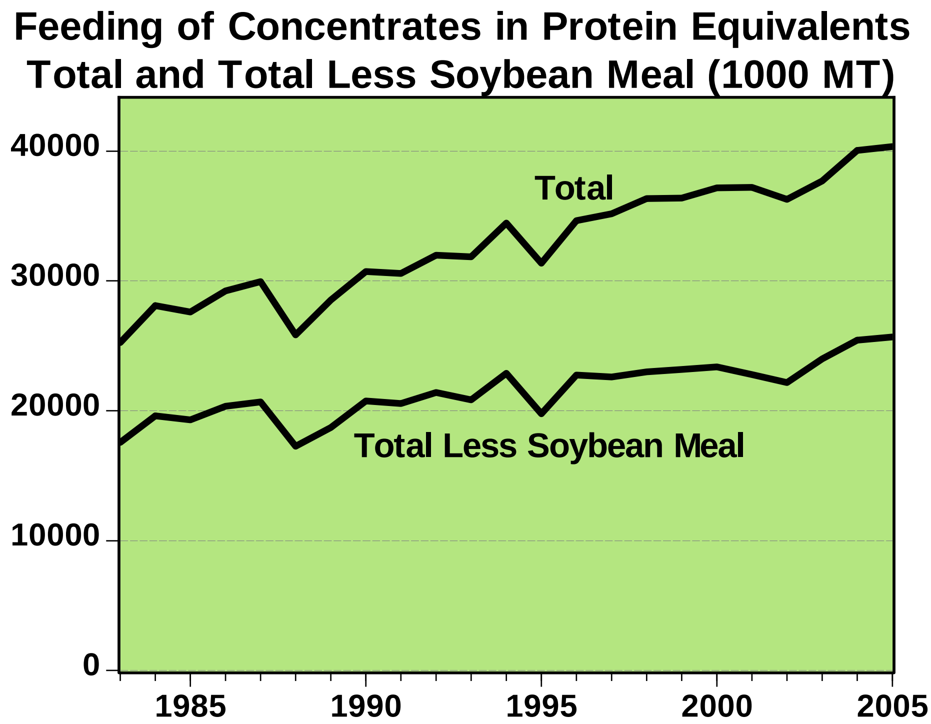


Figure 8.

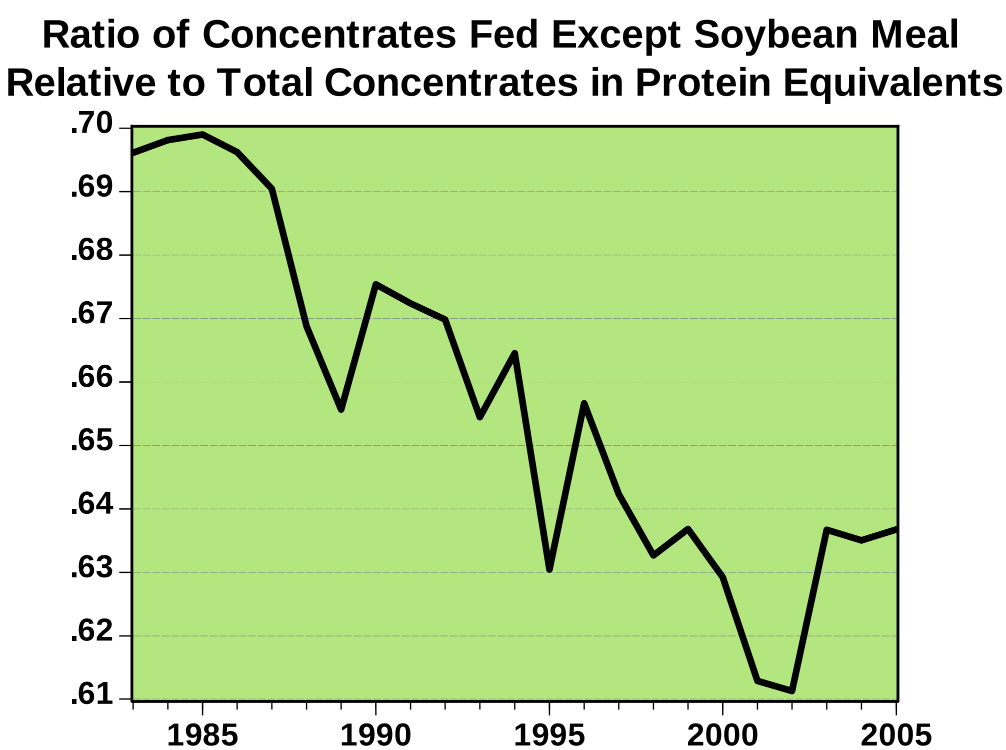


Figure 9.

**Feeding of Concentrates in Energy Equivalents
Total and Total Less Coarse Grain (Bil. Cal.)**

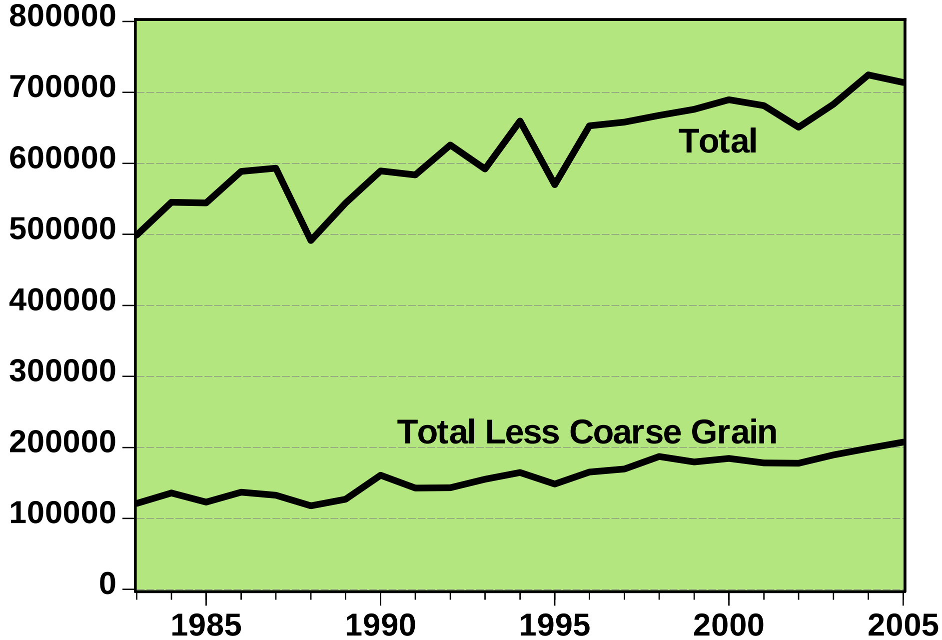
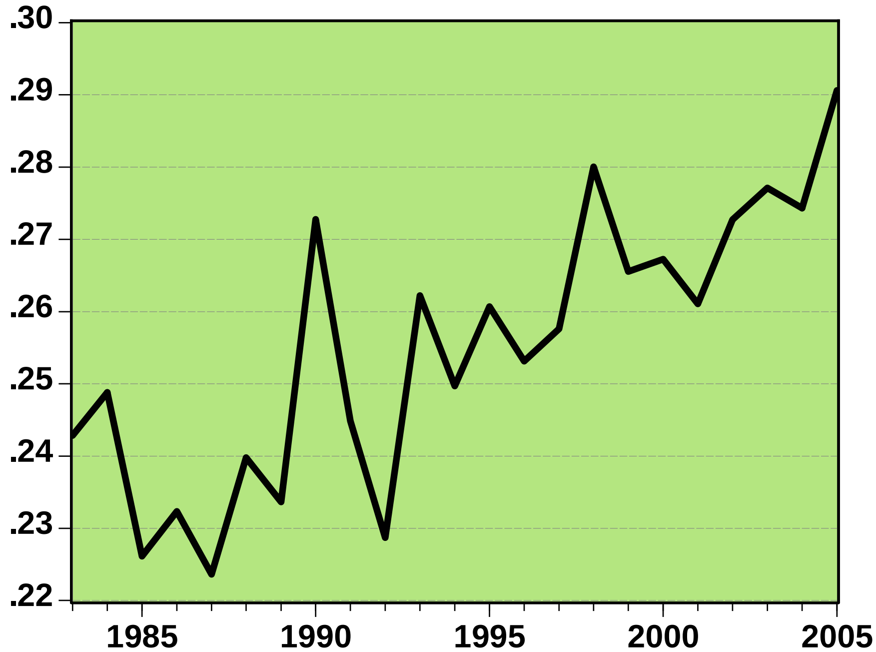


Figure 10.

**Ratio of Concentrates Fed Except Coarse Grains
Relative to Total Concentrates in Energy Equivalents**



Model No. 1

The purpose in deriving the ratios as shown in Figures 8 and 10 was to format variables that could be incorporated into equations designed to forecast feeding of soybean meal and coarse grain. The data base for the regression analysis was annual statistics for crop years 1975 to 2005 from the Economic Research Service of the USDA. Linear relationships were assumed for the effect of the independent variables on the dependent variable.

For the regression equation predicting the amount of soybean meal fed, the codes for the independent variables, the "t" statistics, and the definitions were:

USMLS	10.3	Variable representing standard feeding rates for soybean meal[1]
ILSPD	6.4	Index of livestock prices in real terms
PSMD	-2.2	Deflated price of soybean meal at Decatur, IL
FPCND	-5.8	Deflated U.S. farm price of corn
RUFDPTXSM	-4.7	Ratio of (1) concentrates fed except soybean meal to (2) total concentrates fed in protein equivalents

The R-squared statistic for the equation was .994. The Adjusted R-squared statistic was .992; .984 for an equation without RUFDPTXSM.

For the regression equation predicting the amount of coarse grain fed, the codes for the independent variables, the "t" statistics, and the definitions were:

UCGLS	6.1	Variable representing standard feeding rates for coarse grain[1]
ILSPD	3.3	Index of livestock prices in real terms
FPCND	-3.9	Deflated U.S. farm price of corn
PSMD	-2.4	Deflated price of soybean meal at Decatur, IL
RUFDEGXCG	-3.6	Ratio of (1) concentrates fed except coarse grain to (2) total concentrates fed in energy equivalents

The R-squared statistic for the equation was .882. The Adjusted R-squared statistic was .859; .796 for an equation without RUFDEGXCG.

The results from these equations appeared to validate the effort to incorporate some measure of the availability of feeds other than the one feed or class of feeds being examined. Absolute "t" values of 2.0 or more (more than +2.0 and less than -2.0) are considered to be statistically significant. The R-squared statistics measure what percent of the variation in the dependent variable is associated with the equation. The variables constructed for this research were fairly aggregated. Subsequent steps should be taken to explore more detailed substitution effects.

[1] These feeding rates for soybean meal and coarse grain were constants based on a priori information about the normal conversion of these feeds into beef, pork, broiler, turkey, milk and egg production.

Model No. 2

A second approach was to derive the feeding of soybean meal and coarse grain from regression equations which forecast (1) total protein feeds in livestock rations in protein equivalents and (2) total of all concentrates in livestock rations in energy equivalents. As with Model No. 1, the data base was annual statistics for 1975 to 2005 crop years. Except for the ratios in Model No. 1, the same variables were involved so the definitions are not repeated.

For the regression equation predicting total protein feeds in livestock rations in protein equivalents, the codes for the independent variables and their "t" statistics were:

USMLS	21.2
ILSPD	5.1
PSMD	-1.7
FPCND	-3.0

The R-squared statistic for the equation was .986 and the Adjusted R-squared statistic was .984.

To derive the amount of soybean meal fed to livestock, the amounts of other protein feeds were forecast exogenously for the most part. The feeding of corn gluten feed and meal and DDG was based on projections of ethanol and beverage production. Projections on other protein feeds were basically extension of past trends with some judgment. Utilization of wheat millfeeds was linked to consumption of wheat for food.

The utilization of soybean meal in protein equivalents was estimated by deducting the feeding of the other protein feeds from the total amounts fed as determined by the regression equation. To convert soybean meal in protein equivalents to the total tonnage, a division by .48 was applied, the assumed protein content of soybean meal.

For coarse grain, a similar procedure was followed except that all concentrate feeds were involved, protein feeds as well as energy feeds. For the regression equation predicting total concentrates fed in energy equivalents, the codes for the independent variables and their "t" statistics were;

UCGLS	7.2
ILSPD	4.1
FPCND	-4.3
PSMD	-1.8

The R-squared statistic for the equation was .931 and the Adjusted R-squared statistic was .920.

As was the case for forecasting utilization of soybean meal, utilization of coarse grain was derived from the regression equation by deducting the feeding of concentrates other than coarse grain. These other feeds were generally projected as extension of past trends or were established by the assumption about the production of ethanol. The conversion from energy equivalents to total tonnage was accomplished by dividing the amount fed in energy equivalents by the energy content per metric ton which was estimated to be 3.172 billion calories.

In review of the statistical attributes of the two models, the signs on the variables as shown on the “t” values were as expected. Feeding was positively related to the number of animals as measured by USMLS and UCGLS and livestock prices as measured by ILSPD. Feeding was negatively related to prices on soybean meal (PSMD) and corn (FPCND). In Model No. 1, feeding was negatively related to the competition from other feeds as expressed in the ratios.

Except for soybean meal prices in Model No. 2, the “t” values indicated statistical significance as explanatory variables. The R-squared values were quite strong in the four regression equations. In spite of the less than significant “t” values on soybean meal prices, Model No. 2 was selected for inclusion in AGMOD, an econometric model of U.S. agriculture (Ferris, 1991). The reason relates to the more direct approach to account for the impact of the rapidly expanding availability of the by-product feeds of ethanol production. Furthermore, if DDG is diverted to non feed uses or exported, or if corn oil is extracted from DDG, these changes can be directly incorporated into AGMOD.

AGMOD was developed in the Department of Agricultural Economics at Michigan State University in the 1980s as a microcomputer replacement for the “MSU Agriculture Model” constructed on a mainframe computer. The MSU Agriculture Model had been a project of the department for several years involving a number of faculty and graduate students. AGMOD is commodity specific and includes coarse grain, soybeans, wheat and the major livestock enterprises. The international component includes coarse grain, wheat and oilseeds in various regions of the world. The model is designed to generate annual projections over a 10 to 25 year period.

Forecasting Prices for By-product Feeds of Ethanol Production

Corn predominates the energy feed sector, and soybean meal predominates the protein feed sector (See Table A1). Conceptually, the prices on these two feeds should be strong determinants of prices on the alternative feed sources. One might also incorporate all feedstuffs including hay, silages, haylages, etc. as a part of the livestock feed complex. In this analysis, however, the focus is on concentrate feeds including on-farm utilization of the coarse grains of corn, sorghum grain, oats and barley plus the highly variable feeding of wheat. The procedure was proposed in a prices textbook by this author (Ferris, 1998, 2005).

While not precise, the following procedure can be employed to derive prices for energy and protein:

Convert the price of soybean meal from dollars per short ton (2000 lbs.) to pounds
Convert the price of corn from dollars per bushel (56 lbs.) to pounds
Consider soybean meal as 48% protein and 52% energy
Consider corn as 8.8% protein and 91.2% energy

Then:
PSM=.48xPPRT+.52xPEGY
PCN=.088xPPRT+.912xPEGY

Where:
PSM is the price of 48% soybean meal at Decatur, Il in $/lb
PCN is the spot price of No.2 yellow corn at Chicago in $/lb
PPRT is the price of protein in $/lb
PEGY is the price of energy in $/lb

Solving for PPRT,
Multiply the equation for PSM by (.912/.52) which is 1.754
1.754xPSM=.842xPPRT+.912xPEGY
Subtract this equation from the one for PCN
PCN-1.754xPSM=.088xPPRT+.912xPEGY-.842xPPRT-.912xPEGY
PCN-1.754xPSM=-.754xPPRT
PPRT=(PCN-1.754xPSM)/.754
PPRT=2.326*PSM-1.326*PCN

Solving for PEGY,
Multiply the equation for PCN by (.48/.088) which is 5.455
5.455xPCN=.48xPPRT+4.975xPEGY
Subtract the equation for PSM
5.455xPCN-PSM=.48xPPRT+4.975xPEGY-.48xPPRT-.52xPEGY
5.455xPCN-PSM=4.455xPEGY
PEGY=(5.455xPCN-PSM)/4.455
PEGY=1.224xPCN-.224xPSM

Applying these equations to the price of soybean meal at Decatur, IL and the price of No. 2 corn in Chicago to the crop years of 1975 to 2005 provided the means to calculate synthetic protein and energy prices. These are charted in Figure 11.

While quite variable from year to year, the pattern for protein and energy prices would indicate that there should be no discernable trend in prices on feedstuff over the 1975 to 2005 period. To test this, “value” equations were constructed for the feed by-products of the ethanol industry as follows:
VCNGLT21=(.21xPPRT+.79xPEGY)x2000
VCNGLT60=(.60xPPRT+.40xPEGY)x2000
VDDG=(.281xPPRT+.719xPEGY)x2000
Above, VCNGLT21 represents the “value” of corn gluten feed in dollars per ton, VCNGLT60 represents the “value” of corn gluten meal in dollars per ton, and VDDG represents the “value” of distillers dried grains in dollars per ton, generated by their respective protein and energy contents.

The “values” were plotted against the actual crop year average prices as illustrated in Figures 12, 13 and 14.

Figure 11.

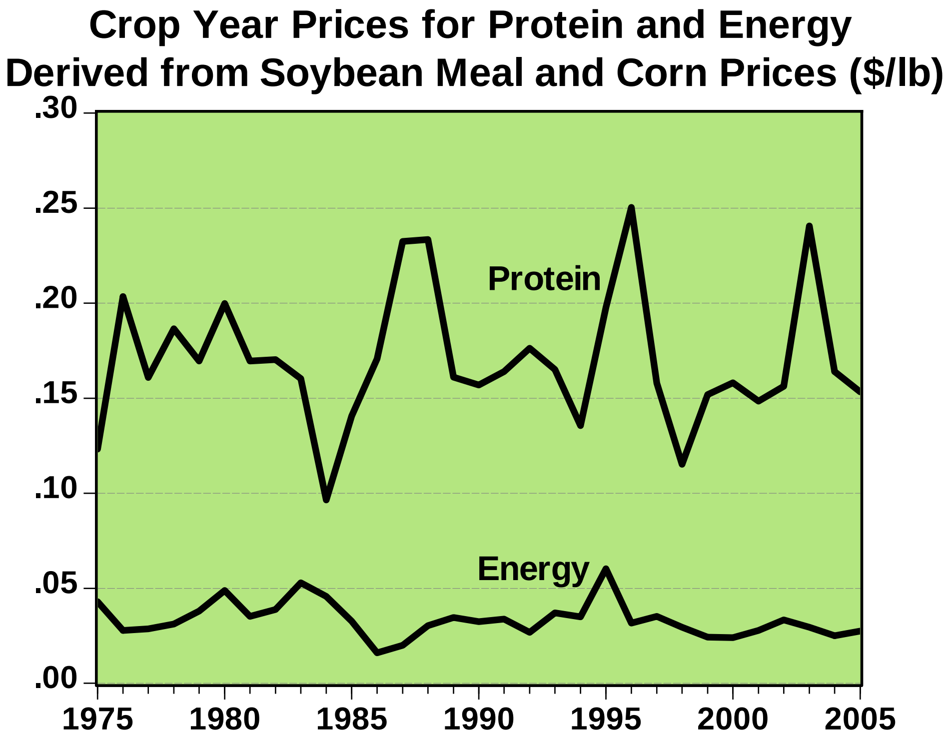


Figure 12.

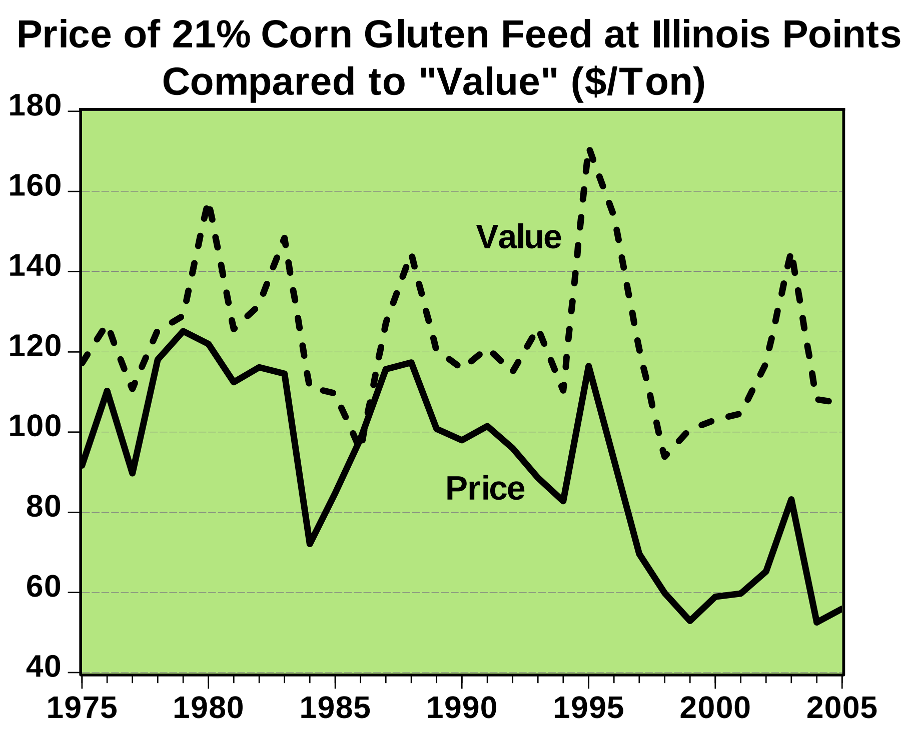


Figure 13.

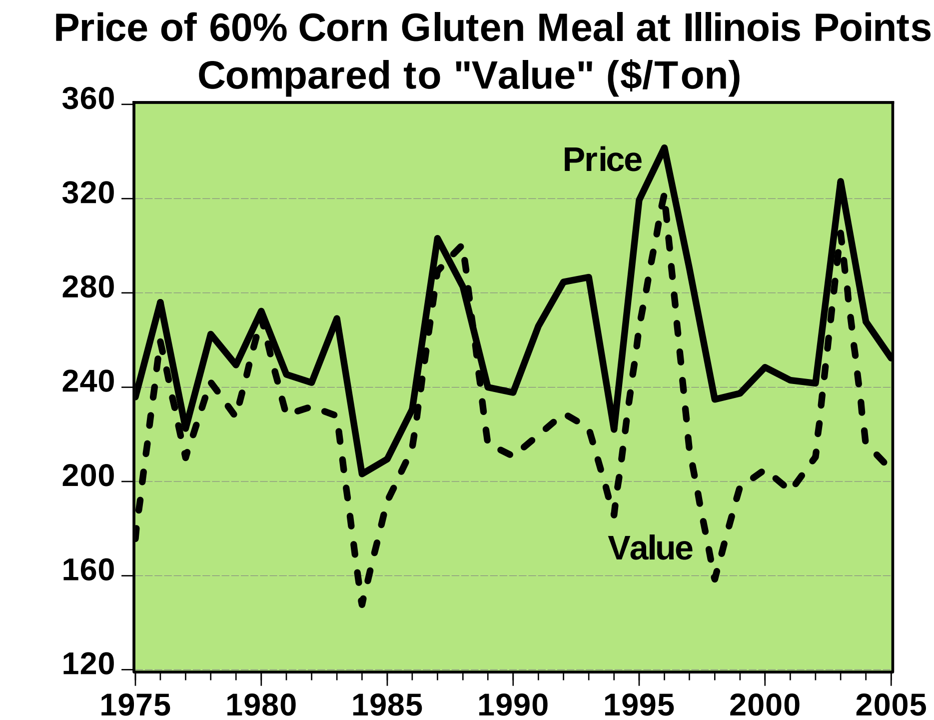
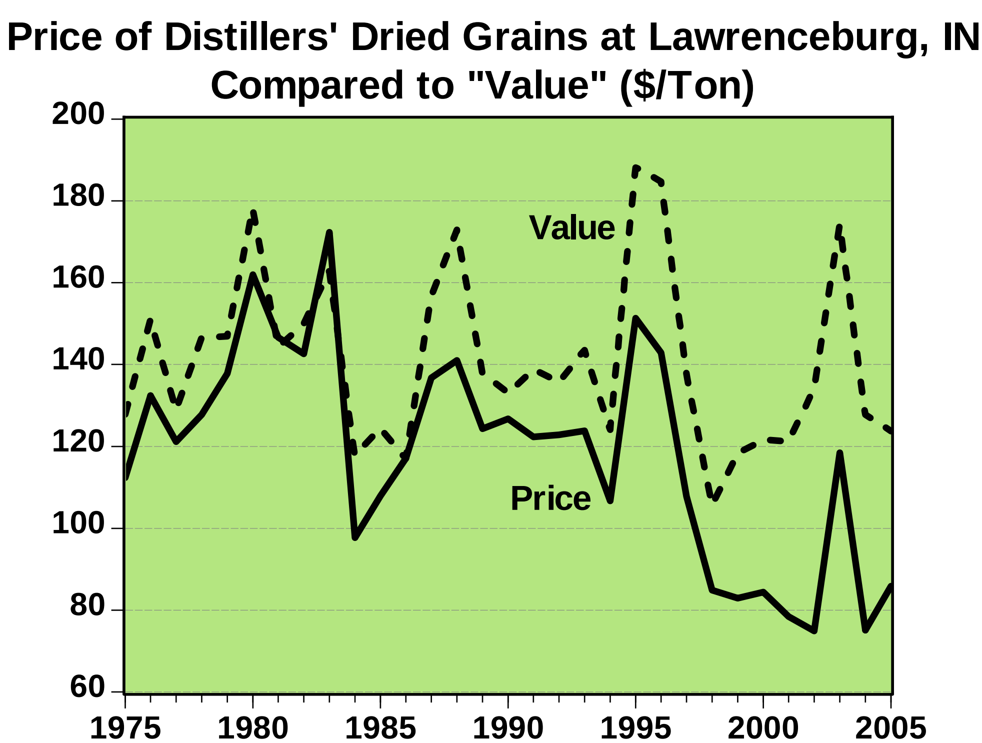


Figure 14.



The term "value" must be interpreted loosely since the location of the markets and the level at which the prices are quoted may not provide comparable bases for this assessment. However, over time, there should be something of a parallel movement between the feed prices and their synthetically derived values.

As a general observation about the results, the procedure tended to over-value the lower protein feeds and under-value corn gluten meal. Secondly, the prices on corn gluten feed and distillers' dried grains declined relative to their values over the 1975 to 2005 period. On the other hand, the prices and values for corn gluten meal did follow a fairly consistent/parallel pattern. The erosion of prices on corn gluten feed and distillers' dried grains relative to their values may reflect their increased availability and livestock producers' unfamiliarity with their handling and utilization. In any case, this procedure to establish feeding values needs improving.

Regardless, the equations do provide a useful approach for forecasting prices on these feeds. The values were employed in a regression analysis for each of the feeds in combination with a variable which represented the relative availability of the feed. This variable was the ratio of (1) the utilization of the feed in protein equivalents to (2) the utilization of all protein feeds in protein equivalents.

The prices selected are representative of the respective feeds and are quoted regularly in the *Feed Outlook* publication of the Economic Research Service of the USDA originating with the USDA's Agricultural Marketing Service. The prices and ratios of utilization relate to marketing years beginning on September 1 for the period of 1975 to 2005.

The results were as follows:

For the price of corn gluten feed (21% protein), the codes for the major independent variables, the "t" statistics, and the definitions were:

VCNGLT21	16.8	Value of 21% corn gluten feed at Illinois points
RUCNGLTTOT	-3.6	Ratio of (1) the utilization of corn gluten feed and meal to (2) the total utilization of protein feeds in protein equivalents

The R-squared statistic for the equation was .969 and the Adjusted R-squared statistic was .964.

For the price of corn gluten meal (60% protein), the results of the equation were:

VCNGL60	24.2	Value of 60% corn gluten feed at Illinois points
RUCNGLTTOT	-0.4	See the above definition.

The R-squared statistic for the equation was .976 and the Adjusted R-squared statistic was .974.

For the price of distillers' dried grain, the results of the equation were:

VDDG	23.0	Value of distillers' dried grains (assumed protein content at 28.1%) at Lawrenceburg, IN
RUDDGTOT	-4.8	Ratio of (1) the utilization of distillers' dried grains to (2) the total utilization of protein feeds in protein equivalents

The R-squared statistic for the equation was .983 and the Adjusted R-squared statistic was .980.

These equations, relating feed values and relative availabilities of these by-products of the ethanol industry to the respective prices, performed quite well over the period of the data base, i.e. marketing years from 1975 to 2005. However, employing these equations to generate price projections over the next, say, 10 years would be fraught with difficulty, particularly considering the anticipated expansion in production of distillers' dried grains. The problem is not intractable but requires the input of expert opinion backed by either quantitative evidence or subjective insights or both.

As an illustration, these price equations were introduced into AGMOD. While the results were reasonable for corn gluten feed and meal, the expanded production of distillers' dried grains drove the prices down to negative levels. This result, of course, forced this author to inject subjectivity into the formulation. In the crop years of 2001 to 2005, the ratio of the price of distillers dried grains to the feed value averaged .63 with a low of .56. With this information, a lower bound was arbitrarily set at .50 for the projection period.

Of course, major gaps in this analysis remain. Questions to be resolved are: (1) How legitimate is the procedure to estimate the synthetic prices on protein and energy? (2) If the procedure has merit, why have prices departed from values and what will be the relationship in the future?

The current and prospective downward pressure on prices of DDG is spurring efforts not only on how to incorporate the feed into more livestock rations but also how to enhance its value in alternative uses. One possibility is to remove the oil as feedstock for the expanding biodiesel industry. Technically, about 10 percent of the volume could be extracted as fuel grade corn oil. A typical price for DDG has been about $80 per short ton. In essence, ethanol plants are selling corn oil for 4 cents per pound while soybean oil is between 25 and 30 cent per pound. At the low end of value, DDG could be burned as a fuel or used as a fertilizer.

<u>Summary and Conclusions</u>

The availability of by-product feeds of the corn wet milling and dry milling industries for domestic livestock producers has expanded rapidly in the past decade with acceleration from dry milling. With incentives in place for ethanol production from the federal *Energy Policy Act of 2005*, the expansion will continue over the next decade, particularly in dry milling. This emerging structural change in the concentrate feed sector calls for new approaches in modeling feed usage and prices.

To integrate the numerous sources of ingredients for livestock rations in equations designed to forecast utilization of major feeds, such as coarse grain and soybean meal, common denominators are needed. By incorporating protein equivalents of other concentrates in a soybean meal usage equation and energy equivalents of other feeds in a coarse grain usage equation, reasonable statistical properties were obtained.

Calculation of synthetic prices of protein and energy can assist in developing price equations on by-product feeds based on their content. However, information is needed on how to assess more accurately their feed value.

Appendix

Table A1.
Compilation of the Protein and Energy Contents of U.S. Livestock Feeds[1]

	Utilization for Feed Crop Year 2003-04 1000 MT	Protein Content Crude, As Fed Percent	Energy Content Bil. Calories per MT
Coarse Grain			
Corn	147,199	8.8	3.19
Sorghum	4,623	11.4	3.11
Oats	2,090	12.1	2.51
Barley	1,611	12.2	2.60
Wheat	5,525	14.9	2.98
Oilseed Meals			
Soybean	29,266	48.0	2.77
Cottonseed	2,528	41.1	2.20
Linseed	172	33.6	2.42
Peanut	108	48.7	2.73
Sunflower	317	41.0	2.45
Canola	1, 867	37.1	3.21
Animal Proteins			
Tankage and meat meal	2,023	59.5	2.47
Fishmeal and solubles	201	57.7	2.71
Milk products	434	33.5	2.96
Grain Protein Feeds			
Corn gluten feed and meal[2]			
Feed	6,185	23.6	2.30
Meal	1,214	43.1	2.96
Distillers' dried grains[3]	5,844	28.1	2.91
Brewers' dried grains[4]	108	25.0	2.15
Other			
Wheat millfeeds	5,995	24.5	2.88
Rice millfeeds	540	12.1	3.10
Alfalfa meal[4]	204	33.1	2.93
Fats and oils	1,298	00.0	7.29
Miscellaneous	1,536	24.5	2.87
Total	228,287	NA	NA

[1] Source for most of the utilization data was the *Feed Situation and Outlook Yearbook*, FDS-2005, April 2005, Economic Research Service, USDA. Source for protein and the derived energy content was Ensminger and Olentine.

[2] Calculated from corn utilized in wet milling and the normal allocation of by-products

[3] Calculated from corn utilized in dry milling and the normal conversion to DDG

[4] Not available in recent years from USDA. Utilization is equal to the last published estimate in *Feed Situation and Outlook Yearbook*, Economic Research Service, USDA.

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