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Forecasting Feed Grain Prices in a Changing Environment

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Abstract

Structural change has been occurring throughout the feed grains sector and has affected commodity markets and price forecasting relationships. Structural changes that have affected feed grains stem from government policy such as the 1996 Farm Act, international trade agreements such as NAFTA, and changing consumer preferences. A statistical test of structural change is provided along with price forecasting models for corn, sorghum, barley, and oats. The models provide a framework to forecast season-average, farm-level prices and gauge the consistency of supply, demand, and price forecasts.

Keywords: Corn, sorghum, barley, oats, feed grains, price forecast, structural change

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Introduction

Structural change in the feed grain market (corn, sorghum, barley, and oats) stems from numerous sources, including changing farm policy and global competition. Increased market orientation and planting flexibility in the United States, provided especially by the 1990 and 1996 Farm Acts, altered producer planting decisions. Global and regional policy changes such as the North American Free Trade Agreement and the WTO's Uruguay Round Agreement on Agriculture have increased market integration and competition. Improved information technology, allowing just-in-time inventory management, has also led to better agribusiness management practices.

All of these changes have had a profound impact on commodity markets and have altered price forecasting relationships. For example, a commodity's stocks-to-use ratio remains an important factor in forecasting that commodity's price, but forecasting models can often be improved by including additional variables.

This report develops season-average farm price forecasts that account for structural change in the feed grains sector. This analysis builds from the forecasting models of Westcott and Hoffman (1999), and Chambers (2002). Evidence of structural change is used to develop forecasts that better fit the current situation.

U.S. Feed Grain Sector: Background

Corn is the dominant feed grain in the United States, while sorghum, barley, and oats make up a small (and shrinking) proportion. Corn is the world's most important feed source and is the base ingredient for most dairy, beef, swine, and poultry feeds (Ash, 1992).

The four feed grains are each used differently in livestock rations because they have different energy and nutrition levels. Corn and sorghum are very close substitutes. Barley and oats—due to high fiber content and other nutritional attributes—are used infrequently for swine and poultry rations. Food and industrial use is another demand component that differentiates the four feed grains. For example, corn is the primary feedstock for U.S. ethanol production, which has increased dramatically in the past 5 years. The highest valued use of barley and oats (if they meet quality standards) is for malt and food uses.

Corn's value of production averaged more than \$18 billion in 1998-2001:

- Corn is planted annually on nearly 80 million acres in the United States.
- Iowa and Illinois are the largest corn producing States, accounting for more than a third of total U.S. production.
- Improved varieties and changes in government programs have led to increased production to the north and west of the traditional Corn Belt.

Sorghum is the most prominent of the three minor feed grains:

- Farmers' cash receipts for sorghum averaged nearly \$921 million per year in 1998-2001.
- Sorghum tolerates hot and dry conditions better than corn, and although it is grown throughout much of the United States, production is concentrated in the Southern Plains.
- Kansas and Texas are the largest producing States, accounting for more than 70 percent of total U.S. sorghum production.

The value of **barley** was \$617 million per year in 1997-2001:

- The proportion of barley used for malt (as opposed to feed) has increased since the 1980s.
- In 2000/01, North Dakota was the largest barley producing state, accounting for 30 percent of total production.

The value of **oats** production was about \$180 million annually (1997-2001):

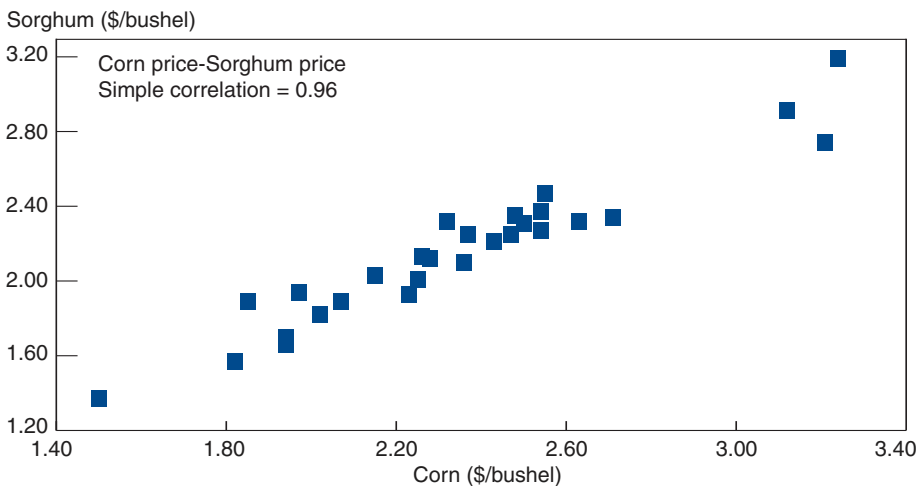
- Oats have steadily declined in significance since the 1950s.
- Oats consumed as food began to increase in the 1980s.
- The United States imports about 30 percent of total oats supply, primarily from Canada.

Factors Determining Price

Prices for agricultural commodities are determined by the interaction of supply and demand. The relationship between supply and demand is reflected in carryover stocks, which are inversely related to price (Plato and Chambers 2004; Westcott and Hoffman; Labys 1973). If total use rises relative to supply, carryover stocks will decline and farm prices will tend to rise. In contrast, rising carryover stocks tend to depress farm prices.

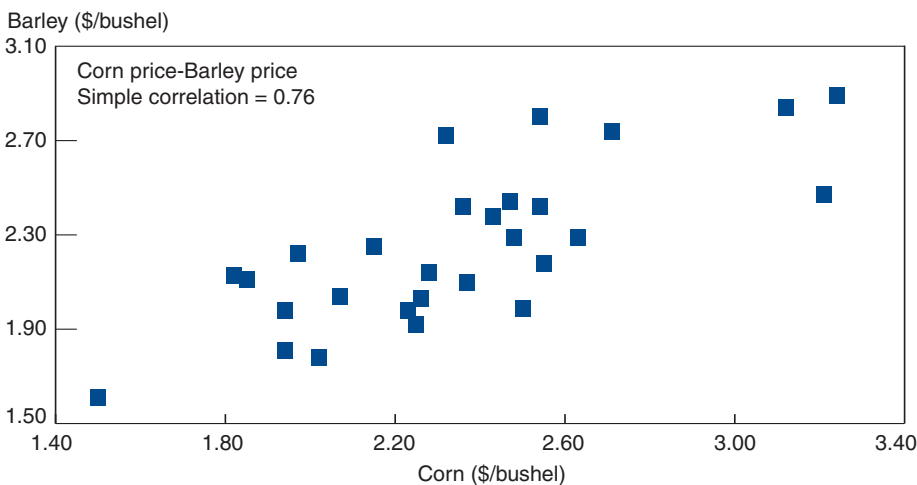
Since feed grains are highly substitutable, prices are influenced by the interaction of supply and demand for the entire feed grain complex. Given corn's primacy in the feed grain market, the prices for sorghum, oats, and barley are strongly correlated with the corn price (figs. 1-3). This is especially true for sorghum, which is most closely substituted with corn. However, some

Figure 1
Sorghum and corn prices, 1975-2002



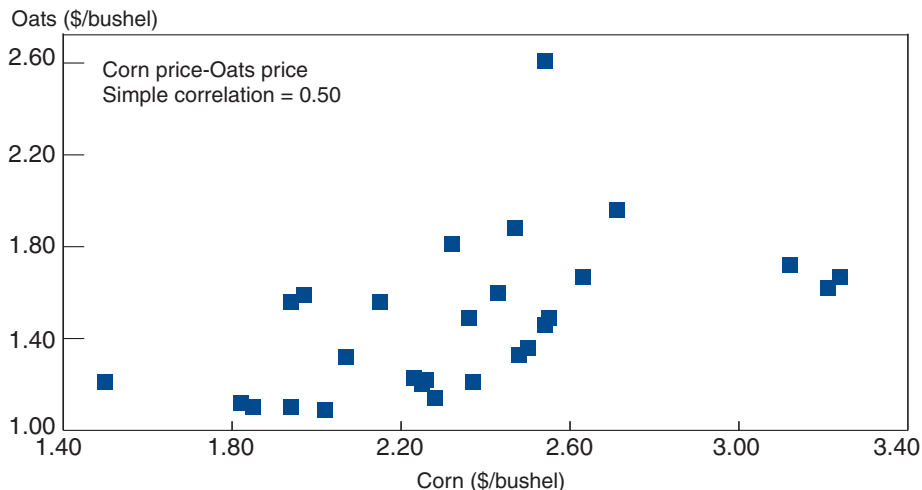
Source: National Agricultural Statistics Service, USDA.

Figure 2
Barley and corn prices, 1975-2002



Source: National Agricultural Statistics Service, USDA.

Figure 3
Oats and corn prices, 1975-2002



Source: National Agricultural Statistics Service, USDA.

grains receive price premiums for higher quality grades that are used for human consumption, most notably for barley and oats. The premiums that these grains obtain for food uses differentiate them from corn.

Supply Factors

Supply consists of beginning stocks, imports, and production. The production of sorghum, barley, and oats has declined for the past decade. This drop has been largely caused by competition from other crops (especially corn and soybeans) that provide farmers with higher returns.

Beginning stocks. Ending stocks from the previous year become the current year's beginning stocks and augment current production in determining total supply.

Imports. Imports are important for barley and oats, but a minor factor for corn and sorghum. The United States imported 20 million bushels of barley in 2000/01 or 6 percent of total supply, mostly from Canada to be used as malt for the beer industry. U.S. barley imports were relatively minor until fusarium head blight (FHB) beset the Northern Plains in the early 1990s. This disease can reduce yields and trigger vomitoxin. The presence of vomitoxin in the Northern Plains forced brewers to find other sources of malting barley, and many turned to Canada and the Western United States.

The United States imports nearly 100 million bushels of oats annually, mostly from Canada, then Finland and Sweden. The United States became a net oats importer in the early 1980s after a long decline in production that began in the 1950s. Canadian production has expanded throughout the 1990s to meet U.S. demand. U.S. imports from Finland and Sweden are more prevalent when the North American oats crop is small.

Production. Domestic production is the primary component of supply and is determined by harvested acreage and yield per acre. Planted acreage

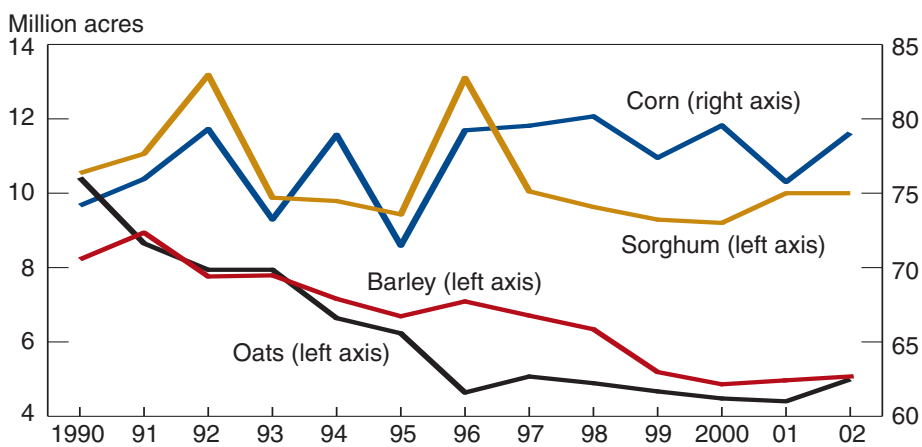
reflects producers' expected returns for a given commodity versus competing crops. This incorporates not only price but also expected yields and government benefits. Agronomic considerations, such as crop rotations, can also influence farm plantings. Acreage planted to sorghum, barley, and oats has declined throughout the 1990s while U.S. corn plantings have increased (fig. 4). Minor feed grain acreage has dropped partly due to improved varieties of competing crops—especially corn and soybeans—which can now be grown profitably outside of the Corn Belt.

U.S. production of all feed grains averaged nearly 260 million metric tons in 2000-2002. Corn accounted for 93 percent of this total followed by sorghum at 4 percent, barley at 2 percent, and oats at less than 1 percent. In 2000-2002, corn production averaged more than 9.5 billion bushels; sorghum, 448 million bushels; barley, 264 million bushels; and oats, 128 million bushels.

Changes in farm policy, especially the move toward planting flexibility, also explain the shift in acreage away from minor feed grains. Government programs have increased market orientation over the past two decades, and the 1996 Farm Act enabled farmers to grow almost any crop on their contract acreage without losing program benefits (this planting flexibility was continued in the 2002 Farm Act) (Young and Westcott, 1996; Westcott, Young, and Price, 2002). Planting flexibility, along with improved corn and soybean varieties, enabled some farmers to shift production away from wheat, sorghum, barley, and oats.

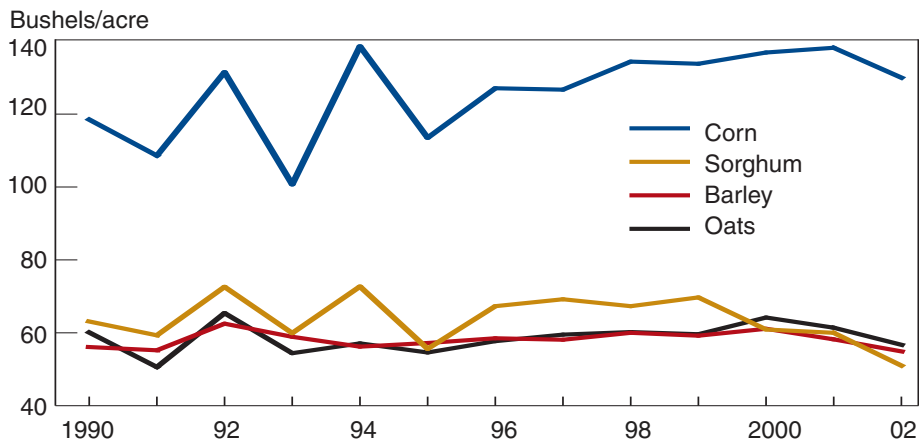
National average yields for sorghum, barley, and oats increased from 1990-2000, but less than the gain for corn (fig. 5). Research into new hybrids is much more intensive for corn than for other feed grains. Agricultural biotechnology could lead to further increases in crop yields. Biotech corn varieties are designed to be insect resistant and/or herbicide tolerant, or could have enhanced specific end-use characteristics desired by consumers. However, biotech varieties of sorghum, barley, and oats are not yet commercially available.

Figure 4
Area planted to feed grains, 1990-2002



Source: National Agricultural Statistics Service, USDA.

Figure 5
Feed grain yields, 1990-2002



Source: National Agricultural Statistics Service, USDA.

Demand Factors

Feed grain demand includes food, seed, and industrial (FSI) uses; feed and residual use; exports; and ending stocks. Domestic use of minor feed grains has been declining in tandem with declines in production.

Food, seed, and industrial use (FSI). FSI use varies significantly among corn, sorghum, barley, and oats. Corn used for ethanol has increased from less than 1 percent of total domestic corn use in 1980 to more than 13 percent in 2003/04. Sorghum can be milled into the same types of products as corn, including food-grade sorghum, sweeteners, and ethanol, but FSI represents a small portion of total sorghum supply and use. By contrast, FSI is a major component of domestic barley use, mainly for malt. Malting barley is higher in value than feed barley. About 65 percent of total barley use in 2002/03 went to FSI. Oats used for food has increased since the mid-1980s, but animal feed still accounts for most of its use. Oats FSI increased significantly in the second half of the 1980s due to growing consumer awareness of the health benefits provided by oat bran.

Seed use is a relatively small component of total demand, and reflects the amount of land planted to a feed grain crop and per-acre seeding rates. Seeding rates vary by State due to different soil types and production practices, but change slowly over time. Therefore, national average seeding rates tend to be fairly stable, and seed use tends to rise or fall with acres planted.

Feed and residual. Data for this category are obtained by subtracting FSI uses, exports, and ending stocks from total supply. As a result, there is some variation that reflects unaccounted statistical measurement errors in other categories of supply and demand. Because data for the other categories are collected by the Commerce Department or obtained from surveys, feed and residual is truly a "residual" component of the supply and demand balance sheet.

Feed use is a derived demand that is closely related to the number of animals on feed as well as the price of competing grains, including feed wheat, nongrain feeds, and numerous byproducts (Westcott and Hoffman).

- Feed and residual use of corn averaged 5.8 billion bushels in 2000-2002 and accounted for 60 percent of total corn use.
- Feed and residual use of sorghum averaged nearly 207 million bushels in 2000-2002 and accounted for 45 percent of total sorghum use.
- Feed and residual barley use averaged 91 million bushels in 2000-2002, accounting for 30 percent of total barley use.
- Feed and residual use of oats averaged 162 million bushels in 2000-2002 and accounted for more than 70 percent of total oats use.

Exports. Exports are relatively more important for corn and sorghum than for barley, and virtually nonexistent for oats. More than 40 percent of the domestic sorghum supply is exported, mostly for animal feed. Mexico is the prime destination for U.S. sorghum, with Japan second. About 17 percent of the U.S. corn supply is exported, and Japan and Mexico are again the most frequent destinations. Although the United States remains the world's largest corn exporter, U.S. producers face increasing competition from South America and China. Barley exports vary significantly from year to year but averaged nearly 38 million bushels between 2000 and 2002. The Middle East, especially Saudi Arabia, is the prime destination for U.S. barley exports. However, the EU is the primary feed barley supplier to the Middle East. Exports of malting barley are minor, in part because of different varietal preferences overseas and strong competition from the EU, Canada, and Australia.

Ending stocks. Ending stocks are inversely related to price and as such are a key market indicator. This is particularly true when stocks are expressed in ratio form, relative to total use. If total use rises relative to supply, ending stocks decline and commodity prices will tend to rise. On the other hand, if supply rises relative to total use, prices tend to decline as ending stocks build.

Structural Change

Many recent events have likely led to structural change in feed grain markets, among them:

- The 1990 and 1996 farm acts greatly increased planting flexibility and led to different cropping patterns among the four feed grains and between them and alternative crops like wheat and soybeans.
- The Canadian Free Trade Agreement (1989) and the North American Free Trade Agreement (1994) increased North American market integration for numerous products, including feed grains.
- The Canadian Wheat Board relinquished control of Canadian oats in 1988, which increased market orientation.
- The Canadian Government's 1995 repeal of the Western Grain Transportation Act eliminated freight subsidies for traditional grains, notably wheat. This encouraged Canadian farmers to produce alternative crops. Increased transportation costs also led to more feed being retained in the production region, which supported an expanding livestock sector.
- The emergence of fusarium head blight and vomitoxin in Northern Plains barley in the early 1990s, and the severe drought in 1988, forced brewers to find other sources of malting barley. Many brewers turned to Canada and the Western United States for malting barley.
- A health trend, beginning in the mid-1980s, boosted U.S. consumption of oats in food.
- Export competition from Argentina and Brazil rose in the 1990s for corn.

I used the Chow forecast test to statistically analyze if structural change has occurred in the U.S. corn market. Corn was chosen because of its dominant position among the feed grains.

The Chow forecast test first estimates a subsample of the model, which is used to predict the values of the dependent variable in the remaining subsample. A large difference between the actual and predicted values is an indication of structural change (Pindyck and Rubinfeld, 1998; EViews 4 User's Guide, 2001).

I used the corn price forecasting model from Westcott and Hoffman to test for structural change. The data in this analysis went from 1975 to 1996, so the Chow test analyzes the likelihood of structural change since 1996.

Equation (1) shows the ordinary least squares (OLS) results of the model run during 1975-96 (the initial subsample used to predict the dependent variable for the remaining subsample). As can be seen in the statistical output, the model performs very well (numbers in parentheses are t-statistics).

$$\begin{aligned} \ln(\text{CP}) = & 0.314 - 0.285 \cdot \ln(\text{K/U}) + 1.617 \cdot (\text{CCC/U}) & (1) \\ & (-8.6) & (3.4) \\ & -0.331 \cdot \text{Dum86} + 0.233 \cdot \ln(\text{LR}) \text{Dum7885} \\ & (-3.8) & (6.7) \end{aligned}$$

The large F-statistic (4.18) in the Chow test indicates that the predicted and actual values from the remaining subsample (1997-2002) are significantly different at the 99-percent level. (See (2).) This is a strong statistical indication of structural change in the corn market since 1996. When the Westcott and Hoffman model is run for 1975-2002, the independent variables remain statistically significant (though their coefficients change) but the adjusted R² drops from 0.89 to 0.79, indicating that other variables are needed to account for the structural change.

Chow forecast test from 1997-2002 (2)

F-statistic = 4.18	Probability = 0.009
Log likelihood ratio = 25.36	Probability = 0.0003

This exercise demonstrates substantial structural change in the corn market, even as recently as the late 1990s. With this information, I develop price-forecasting models using OLS that account for structural change.

Corn Price Model

Data used for the corn price equation were from 1990 to 2002. Starting the sample with 1990 avoids the need to account for the nonrecourse loan program and other government policies, whose price effects were larger in earlier years. Although the Chow test identified a structural break after 1996, the forecasting model used data from 1990 to 2002 to reflect the planting flexibility given farmers after the 1990 Farm Act. The 1990 Farm Act increased market orientation by, among other things, introducing "flex acres" and revising the farmer-owned reserve program (Young and Westcott). This has had a tremendous impact on farm planting decisions.

Equation (3) indicates that the stocks-to-use ratio remains a very important explanatory variable for corn price, but increased competition in global markets also is important. Notably, export competition from South America has increased throughout the 1990s (fig. 6). About 85 percent of the variation in Ln(CP) is explained by the independent variables in the equation. The coefficient for "Ln(K/U)" exceeds the 99 percent significance level (i.e., we are 99 percent certain that the coefficient is not zero), and the coefficient for "Ln(Arg Exp + Braz Exp)" exceeds the 95-percent confidence level. The signs on both coefficients are negative, as expected.

R² = 0.907
 Adj. R² = 0.886
 F-value = 41.65
 Durbin-Watson = 1.93
 Estimation period, 1975-96

Notation:

Ln = Natural log
 CP = Corn price (dollars/bushel)
 K = Corn stocks (million bushels)
 U = Total corn utilization (million bushels)
 CCC = Corn government owned stocks (million bushels)
 LR = Corn loan rate (Dollars/bushel)
 Dum86 = Dummy variable equal to 1 in 1986 and 0 otherwise¹
 Dum7885 = Dummy variable equal to 1 in 1978-85 and 0 otherwise¹

¹For dummy variable explanation, see Westcott and Hoffman.

$$\ln(\text{CP}) = 1.10 - 0.354 \cdot \ln(\text{K/U}) - 0.108 \cdot \ln(\text{Arg Exp} + \text{Braz Exp}) \quad (3)$$

(-7.35)
(-2.71)

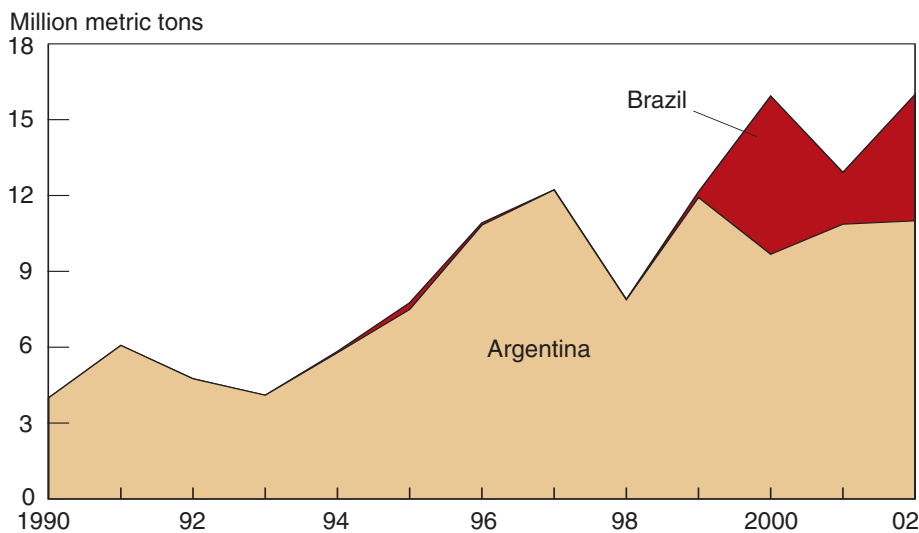
$R^2 = 0.85$
 Adj. $R^2 = 0.82$
 F-value = 29.1
 Durbin-Watson = 1.73
 Estimation period, 1990-2002

Notation:

Ln = Natural log
 CP = Corn price (dollars/bushel)
 K = Corn stocks (million bushels)
 U = Total corn utilization (million bushels)
 Arg Exp = Argentina market year corn exports (1,000 MT)
 Braz Exp = Brazil market year corn exports (1,000 MT)

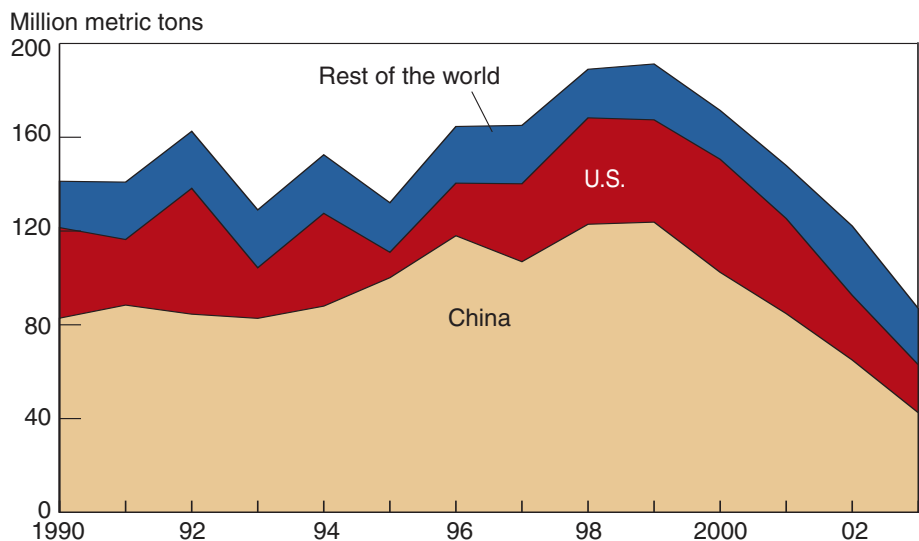
Major competition in corn export markets has also come from China, but China trade was not statistically significant in the models. This was unexpected because the China market has been a major factor in global corn markets. However, China's domestic policies in the 1990s hinged on internal political versus market issues. For example, China built and maintained very large corn stocks in the 1990s and then started to reduce stocks in 2000 (fig. 7). While Chinese trade influenced the U.S. price, this effect is implicitly captured in the model by the U.S. stocks-to-use variable.

Figure 6
South American corn exports trend upward



Source: Foreign Agricultural Service, USDA.

Figure 7
Global corn stocks rose in the 1990s



Source: Foreign Agricultural Service, USDA.

When China first entered the WTO in December 2001, it was widely expected that their corn exports would decline but they actually increased (Gale and Hansen, 2003) due largely to their drawing down stocks. China's corn exports peaked in 2002/03 at over 15 million tons. Market disciplines under the WTO are expected to dampen Chinese corn exports over time. USDA's baseline shows China's exports declining in every year of the projections to 1.3 million tons in 2013 (USDA, 2004). USDA projections also indicate that China will increase corn imports and become a net corn importer in 2009/10 (Gale, 2004).

Sorghum Price Model

The sorghum model (equation 4) is much simpler than the corn model because the corn price is such a dominant factor. Reflecting relative feeding values as well as differences in geographic regional production, season-average national sorghum prices historically are about 90-95 percent of the U.S. season-average corn price. However, over the past several years, sorghum prices have averaged near corn prices nationally. (fig. 8).

$$SP = -0.1134 + 0.984 \cdot CP \quad (4)$$

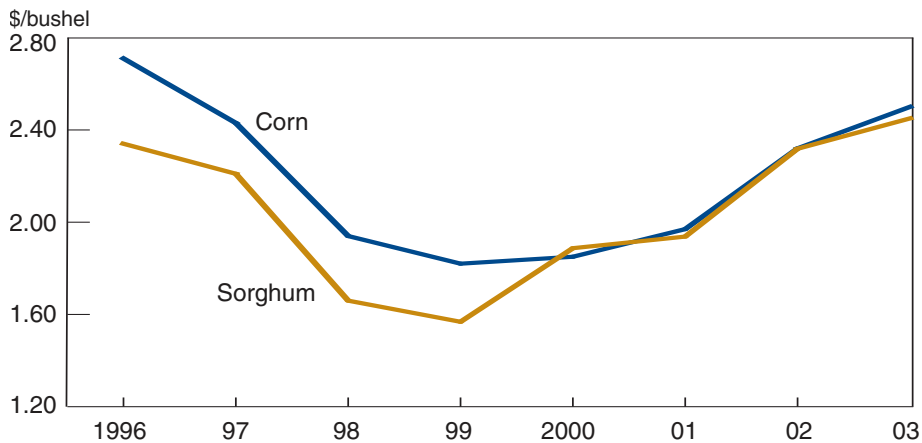
(10.9)

The model accounts for about 92 percent of the total variability in sorghum prices. The coefficient for "CP" was statistically significant at the 99-percent confidence level. In an alternative specification, the sorghum stocks-to-use ratio was not statistically significant primarily because the sorghum market follows the corn market so closely.

$R^2 = 0.915$
 Adj. $R^2 = 0.908$
 F-value = 118.799
 Durbin-Watson = 1.467
 Estimation period 1990-2002

Notation:
 SP = Sorghum price (dollars/bushel)
 CP = Corn price (dollars/bushel)

Figure 8
Little difference between corn and sorghum prices in 2000-03



Source: National Agricultural Statistics Service, USDA.

Barley Price Equation

Data for the barley price equation went from 1987 to 2002 because this is about the time that the ratio of food, seed, and industrial use (FSI) began to increase relative to total barley supply, an important element of structural change (fig. 9). Food, seed, and industrial use (especially malting barley) has increased as a share of total supply, which is important because malt earns a premium relative to feed barley. Therefore, the barley price should rise as the ratio of FSI to total supply increases. Equation (5) shows the model forecast.

$$\begin{aligned} \text{Ln (ABP)} = & 0.586 + 0.685 \cdot \text{Ln (CP)} + 0.314 \cdot \text{Ln (FSI/Supply)} & (5) \\ & (6.28) & (4.19) \\ & - 0.00072 \cdot \Delta\text{Supply} \\ & (-2.84) \end{aligned}$$

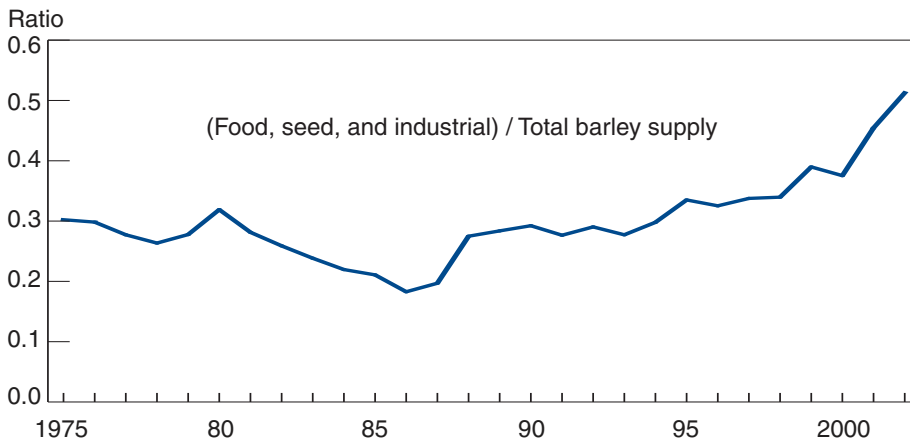
The model accounts for 84 percent of the variability in “Ln (ABP).” In an alternative specification, the stocks-to-use ratio was not statistically significant and thus was not used in the final model. However, the year-over-year change in total U.S. barley supply (“ΔSupply”) was used. The feed component of barley is closely related to corn. Therefore, the corn price was an important variable in the equation. The coefficients for “CP” and “(FSI/Supply)” were significant at better than the 99 percent confidence level. The coefficient for “ΔSupply” was significant at the 98.5-percent confidence level.

R² = 0.837
Adj. R² = 0.796
F-value = 20.51
Durbin-Watson = 1.73
Estimation period, 1987-2002

Notation:

Ln = Natural log
ABP = All barley price (dollars/bushel)
CP = Corn price (dollars/bushel)
FSI = U.S. barley food, seed, and industrial use
Supply = U.S. barley supply
ΔSupply = Year-over-year change in U.S. barley supply

Figure 9
Amount of barley used as malt is increasing



Source: Economic Research Service, USDA.

Oats Price Model

Data for the oats model spanned 1985-2002 to account for the increase in oats food consumption, which began in the mid-1980s. Equation (6) shows the price forecasting equation.

$$OP = -2.79 + 0.473 \cdot CP + 2.33 \cdot (FAIU/FAIU_{-1}) + 0.239 \cdot (U/K) \quad (6)$$

(3.98) (5.81) (2.80)

Corn price played an important forecasting role for oats as with the other minor feed grains. The stocks-to-use ratio was inverted (i.e. the use-to-stocks ratio) to improve the fit; this suggests nonlinearity in the relationship between stocks/use and oats price. The variable “FAIU” accounts for the nonfeed component of the oats market and is mostly food use.

The more commonly reported food, seed, and industrial use (FSI) variable was not used in the model because of the seed component. Seed is a minor use for most feed grains. However, since oats are commonly used as a cover crop or in pastures, seed use can be a much larger proportion of FSI relative to seed use for other feed grains. To separate food use from the rest of the market (because oats used for food are of a higher quality and earn a premium) the variable “FAIU/FAIU₋₁” accounts for the year-over-year change in oats used for food. The coefficients for the variables “CP” and “FAIU/FAIU₋₁” were statistically significant at the 99-percent confidence level. The coefficient for the variable “U/K” was significant at the 95-percent confidence level.

$R^2 = 0.80$
Adj. $R^2 = 0.75$
F-value = 18.4
Durbin-Watson = 2.06
Estimation period, 1985-2002

Notation:

OP = Oats price (dollars/bushel)
CP = Corn price (dollars/bushel)
FAIU = Food, alcohol, and industrial use (million bushels)
K = Oats stocks (million bushels)
U = Total oats utilization (million bushels)

Model Evaluation

Historical and forecast prices for the four feed grains (figs. 10-13) show that the price models track actual prices well. The sorghum model performed best, with a mean absolute error of 9.3 cents/bushel. The mean absolute error was highest for oats at 13.7-cents/bushel.

The models also capture turning point errors fairly well. A turning point error can be defined statistically when the following inequalities hold:

$$(\text{Predicted}_t - \text{Actual}_{t-1})(\text{Actual}_t - \text{Actual}_{t-1}) < 0 \quad (7)$$

or

$$(\text{Predicted}_t - \text{Predicted}_{t-1})(\text{Actual}_t - \text{Actual}_{t-1}) < 0 \quad (8)$$

Predicted prices are derived from the models and actual prices are weighted season-average prices received by farmers as reported by the National Agricultural Statistics Service. The subscripts "t" and "t-1" represent current and lagged time periods. Thus, the statistic measures whether predicted year-to-year changes from the models are directionally the same as changes in actual prices.

Turning point errors can occur in two ways: (1) when actual prices indicate a turning point but predicted prices do not, and (2) when actual prices do not indicate a turning point but predicted prices show a turning point (Westcott and Hoffman). The different definitions for the occurrence of a turning point in equations (7) and (8) relate to whether the change in the predicted price is measured relative to the previous year's actual price (7) or the previous year's predicted price (8). Both measures are useful, but the appropriate measure depends on the intended use of the model. For short-term forecasting where the previous year's actual price is known, the former measure is appropriate. For longer term forecasts where the previous year's actual price is not known, the latter definition is better. Since these price models are intended for both short-term and long-term forecasting, both definitions are used (table 1).

Figure 10
Corn price: actual and model estimates

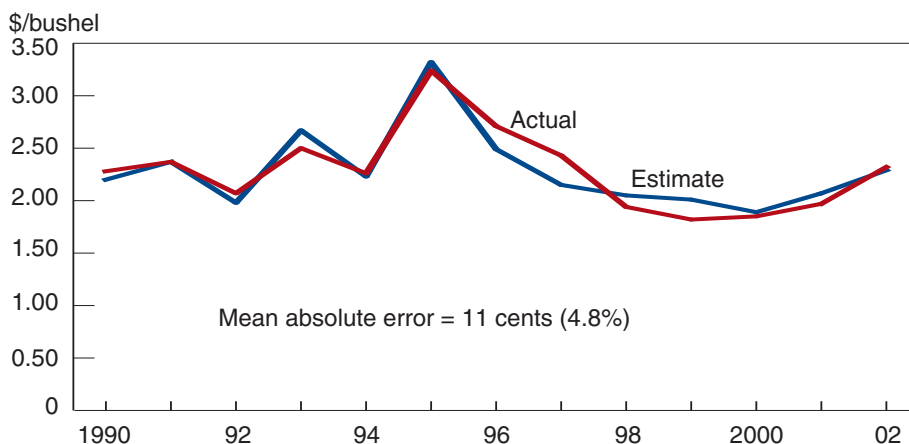


Figure 11
Sorghum price: actual and model estimates

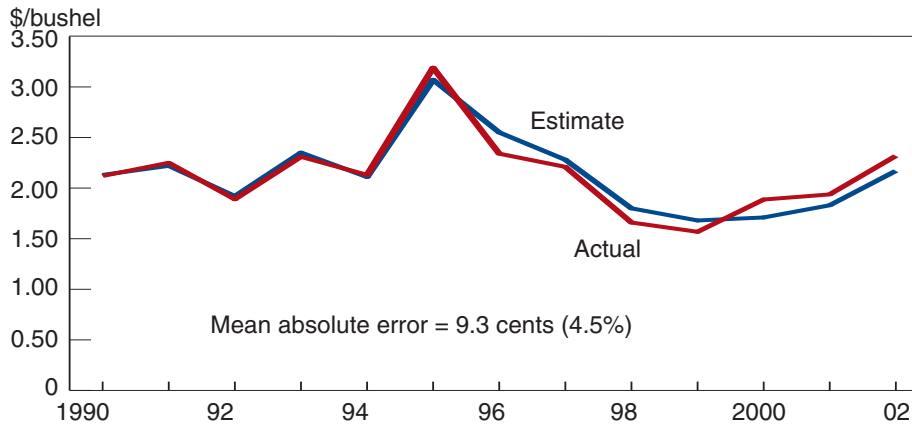


Figure 12
Barley price: actual and model estimates

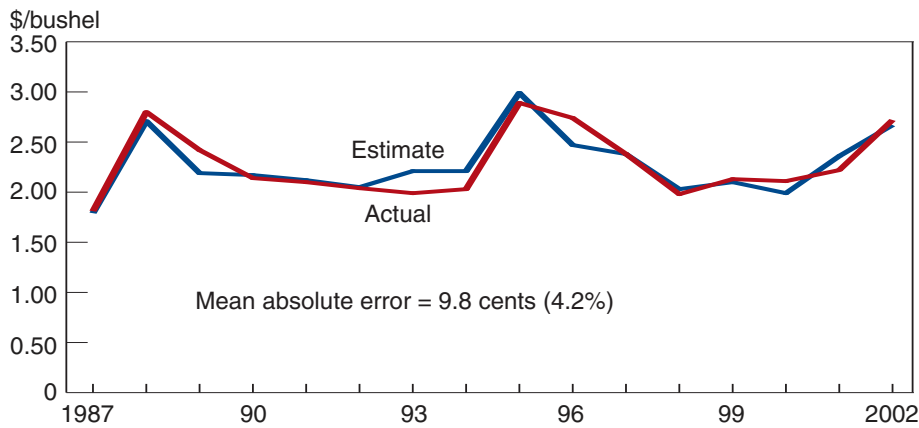
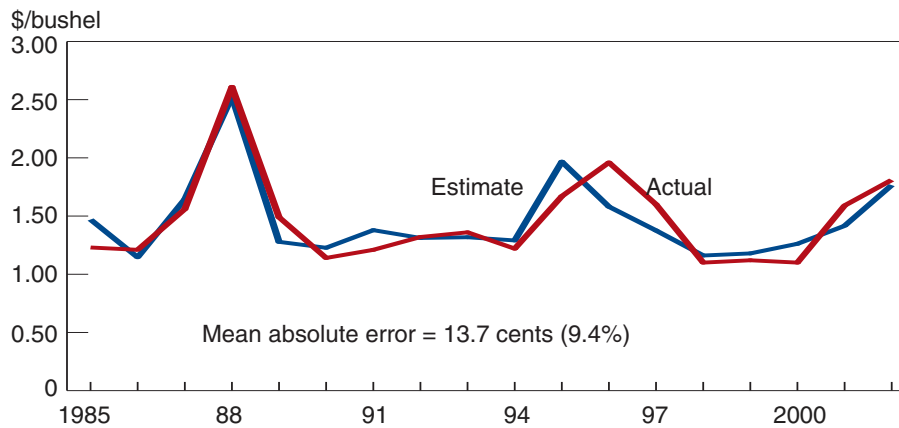


Figure 13
Oats price: actual and model estimates



**Table 1—Turning point errors for the commodity pricing models
 (year of occurrence)**

Grain	Lagged actual prices are used in the turning point error definition	Lagged predicted prices are used in the turning point error definition
Corn	1 (1999)	1 (2000)
Sorghum	2 (1999, 2001)	none
Barley	1 (1993)	1 (1993)
Oats	3 (1993, 1996, 2000)	3 (1992, 1996, 2000)

Conclusions

This report provides an overview of the U.S. feed grain sector, a description of recent structural change, and forecasting equations for farm-level, season-average prices that account for structural change. A statistical test identified structural change in the corn market occurring after 1996. Other structural changes, particularly policy related, likely occurred prior to then throughout the feed grain sector and, indeed, throughout agriculture.

Price forecasting equations presented in this report build off previous models. Changes in the models to account for structural change included the choice of years used in the regression analysis as well as the inclusion of new independent variables.

The four price forecasting models are a useful foundation for analyzing feed grain markets. The simplicity of the models and modest data requirements enable price-forecasting applications in conjunction with market analysis of supply and demand conditions. These models provide a statistical framework for forecasting prices and for gauging the consistency of supply, demand, and price forecasts.

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