SIMPLIFIED SHORT-RUN PRICE FORECASTING MODELS FOR WHEAT AND CORN

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ABSTRACT

Models were developed which are simple enough for use by farmers and rural elevators in short-term price forecasting. The models express annual U.S. wheat and corn prices as a function of world stocks and projected levels of world production and consumption. The wheat model had a 6.6% average error in annul prices over the 12 years of data and the corn model averaged 1.2% error over 11 years of data. The models predicted 1986/87 prices to increase 6% for wheat and decrease 20% for corn using U.S.D.A. projections of production and consumption as of August, 1986. Price responsiveness indicators were also examined.

INTRODUCTION

Prices of agricultural commodities are volatile when compared to many other economic goods. The price volatility exists both within and among years. For example, between 1970 and1985, average annual variation in corn prices was 17% or$.44/bu. (USDA, Ag. Statistics, 1985). Agricultural commodities are also volatile over short periods of time. The price of corn in 1982 and the price of wheat in 1976 changed more than 30% in less than 12 months (Chicago Board of Trade, 1984). The average within-year price variation on wheat between 1974 and 1983 was 25.4% or $.87/bu. (Chicago Board of Trade, 1984).

Price uncertainty in agricultural commodities is a persistent problem for producers and merchants of the commodities and producers and purchsers rarely have price forecasting tools which are readily adaptable to their management systems. Producers typically must make price sensitive production decisions before they plant a crop with little indication of price levels at the time of harvest. Producers and merchants may also lose revenue through poorly timed marketing decisions because of lack of accurate price expectations.

Economics literature provides numerous price forecasting models for agricultural commodities, but they consist primarily of complex structural long-run models. For example, Roy and Ireland (1975) developed a simultaneous equations model to forecast annual U.S. sorghum prices with a set of supply and demand relationships for determining market prices. Paddock (1985) used the same general approach to forecast quarterly and annual wheat prices. Johnson et al. (1986) likewise employed a multi-sector econometric model to forecast annual prices for corn and wheat. These types of forecasting tools are productive for policy analysis and long-range price projections but have limited application for short-term (within-year) price forecasts. In addition, they require extensive knowledge of econometric modeling and computers, which few business managers possess.

If producers and merchants had a simplified price forecasting model for commodities, such as corn and wheat, they might improve the profitability of their production and marketing decisions. They need a method for price forecasting that is accurate, but it should also be simple enough to use easily. The objective of this study was therefore to develop a short-run (up to one year) price forecasting model for corn and wheat that is readily usable by producers and merchants to complement the general price forecasts available from various public and private agencies.

METHODS AND PROCEDURES

The steps involved in the analysis included: (a) developing price forecasting models for wheat and corn based on economic principles, (b) collecting data and estimating coefficients in the models, and (c) testing, analyzing and evaluating the models.

Models

Wheat and corn prices are established by interaction of demand and supply forces. Supply relationships are established primarily by cost factors and supply is shifted by forces such as weather, government programs, and alternative uses of production resources. The demands for corn and wheat, in domestic and export markets, are shifted by changes in population, incomes, values and quantities of other products in which corn is an input, prices of competing products, and consumer tastes and preferences (in both domestic and export markets).

These relatively complex relationships may be captured in simpler relationships between price and indicators of production, consumption, and inventory or stock levels. For example, when demand for wheat decreases (supply constant), price decreases and stocks in storage rise. When supply of wheat decreases, price increases and stocks decline. When consumption increases, other things constant, prices are bid up, etc. The relationship between price and each of these factors is expected to be non-linear because prices are more sensitive to small changes in demand or supply forces when stocks, production, and consumption are small and less sensitive when they are large.

For this study, U.S. prices of wheat and corn were expressed as functions of world stocks, utilization (consumption plus losses) and production of the respective grains because the U.S. market reflects global conditions in the corn and wheat markets for the period analyzed. For example:

$$Pw = f(Sw, Uw, PDw)$$
$$Pc = g(Sc, Uc, PDc)$$

where: Pw,Pc = price of wheat and corn, respectively
Sw,Sc = stock levels of wheat and corn, respectively
Uw,Uc = utilization levels of wheat and corn
PDw,PDc = production levels of wheat and corn

In order to capture the expected nonlinear relationships the natural logarithms of variables were used in the model, abbreviated by the symbol "ln".

Various combinations of the dependent price variable evaluated included annual U.S. average corn and wheat prices in

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nominal terms and adjusted for inflation by using various price indexes (adjusted prices), and the natural log of adjusted prices.

Combinations of independent variables tested in the models included ending stock levels, beginning stock levels, production levels, utilization levels, and ratios such as beginning stocks divided by production and beginning stocks divided by utilization, and stocks, utilization, and production lagged one year. These variables were examined at world and U.S. levels. The natural logs of these variables were also evaluated.

The model was estimated by Ordinary Least Squares regression analysis. The estimated models were evaluated statistically by examining R-squared values for the estimated equations, statistical significance of the explanatory variable coefficients and theoretical consistency of coefficient signs. Theory suggests that production and stock variables should have negative coefficient signs while the utilization coefficient sign should be postive. After selecting the best statistical models, forecasted prices were compared with the actual prices.

Responsiveness of price with respect to each variable was evaluated. Price flexibility with repect to each variable shows the percentage change in price associated with a one percent change in the variable. For example, price flexibility of stocks was calculated as ($\partial P / \partial S$) (S/P) where S and P are mean values of stocks and price, respectively. This procedure was followed for both corn and wheat models.

Data

For both corn and wheat, no data were collected prior to the year 1974. In 1973 and 1974 significant structural changes occurred in international grain markets. Including data prior to 1974 might decrease the accuracy of a model designed to forecast current prices.

Data were collected for corn and wheat on a crop marketing year basis. Marketing years were October/September for corn and June/July for wheat. This means, for example, that in the 1974/75 year for corn the data were for the year October 1974 through September 1975. For the 1980-81 year for wheat the data were for the year July 1980 through June 1981.

The price data collected were crop marketing year asking prices at Rotterdam for 30-day delivery, as shown by Hamburg Mercantile Exchange. Prices were quoted for U.S. no. 2 Northern Spring wheat at 14% moisture. For corn the prices were for U.S. no. 3 Yellow corn.

It was not certain whether the estimation models should use nominal or real prices, so a number of price indexes were collected so that the price could be adjusted. The indexes collected and their sources included (a) the GNP implicit price deflator and the index of prices received by farmers (U.S.D.A., June 1985) and (b) the world non-fuel commodity price index, the world food price index and the agricultural raw products price index (International Monetary Fund, 1986). These price indexes were converted from a calendar year to a marketing year basis by multiplying the price index of the first year by the percentage of the crop that fell into that year and then adding it to the percentage of the price index for the next year that fell in the that marketing year. The price indexes were all converted to a base year of 1985/86.

For both wheat and corn, world production levels, total world utilization levels, and ending world stock levels were in millions of metric tons and were collected for the marketing years 1974/75 through 1985/86 (U.S.D.A., Sept. 1980, July 1982, Dec. 1984, Sept. 1986). U.S. production, utilization and ending stock levels and net trade levels (exports minus imports) were also collected (U.S.D.A., 1985).

FINDINGS

Several model forms were evaluated. Beginning stock levels were better predictors of prices than were ending stocks in all cases. Ratio variables such as stock levels as a percentage of production and stock levels as a percentage of utilization were also less effective than separated variables. U.S. data did not yield results as reliable as the world data.

Wheat

The best (semi-log) model for wheat used the nominal (unadjusted) price as the dependent variable. The equation selected for estimating wheat prices was:

$$Pw = \underset{(-2.55)}{-1004.0} - \underset{(-3.61)}{177.04(\ln SBw)} + \underset{(3.96)}{936.83(\ln Uw)} - \underset{(-3.55)}{610.43(\ln PDw)} \quad (1)$$

where Pw = average marketing nominal price of wheat in Rotterdam U.S. dollars per metric ton.

SBw = world marketing year beginning stocks of wheat, millions of metric tons.

Uw = world marketing year utilization of wheat millions of metric tons.

PDw = world marketing year production of wheat, millions of metric tons.

ln = natural logarithm.

The coefficient t-values are in paratheses below the estimated parameters. All parameter estimates were statistically significant at the .01 significance level. The R^2 for the estimated equation was .674, indicating that the model explained 67.4% of the variation in wheat prices over the 12-year period (1974/75-1985/86). The average percentage error for the wheat price equation over the 12-year peroid was 6.6%; i.e., the actual price average being 6.6% above or below the price predicted by the equation.

One measure of price responsiveness, the partial derivative of price with respect to each explanatory variable, measures the change in price resulting from a one unit change in the variable. The partial derivative for the stock utilization, and production variables were $\partial Pw/\partial SBw$ = (-177.04/SBw), $\partial Pw/\partial Uw$ = (936.83/Uw), and $\partial Pw/\partial PDw$ = (610.48/PDw), respectively. At different levels of production, utilization and stocks the price responsiveness is different. Price responiveness measured at "low", "high", and mean level of the variables responsiveness are shown in Table 1. At the mean value for SBw = 88.9, a change (increase) in world beginning stocks of one million metric tons causes wheat prices to change (decrease) by $1.99 per metric ton. At the mean value for Uw = 433, a one million metric ton change (increase) in utilization causes a $2.16 per metric ton change (increase) in the price of wheat. At the mean value of PDw = 439, a one million metric ton change (increase) in the level of production causes a $1.39 per metric ton change (decrease) in the price of wheat.

The price flexibilities, the percentage change in price from a one percent change in explanatory variable, measured at the means of the variables are also shown in Table 1 at the low, high and mean values for the twelve years of data. The price flexibility at the mean for the stock variable is = Pw/ SBw (mean SBw/mean Pw) = -1.99 (88.9/174.62) = -1.01. This indicates that for a one percent change (increase) in the beginning world stock level, the price of wheat will change (decrease) by 1.01%. The price flexibilities of utilization and production were calculated similarly.

The indicators of price flexibility show that wheat prices are most sensitive to changes in world utilization, next to changes in production, and least sensitive to change in stocks, other things constant. Price is more sensitive to changes in all three variables at lower prices.

Table 1. Measures of Price Responsiveness for Wheat.

Variable (X)	Levels of Variables (Xi)	Corresponding Price[1]	(∂Pw/ ∂Xi)	Price Flexi-bility
	million metric tons	- - $/metric ton - -		%
Stocks	63.7 (low)	233.63	-2.78	- .76
	88.9 (mean)	174.62	-1.99	-1.01
	125.7 (high)	113.30	-1.41	-1.56
Utilization	367 (low)	19.69	2.55	47.52
	433 (mean)	174.62	2.16	5.36
	495 (high)	299.99	1.89	3.12
Production	357 (low)	300.83	-1.71	-2.03
	439 (mean)	174.62	-1.39	-3.49
	511 (high)	81.91	-1.19	-7.42

[1]Assuming other variables at mean levels.

Corn

The best-fit corn model (semi-log) used an adjusted price, the natural log of the price divided by the GNP deflator, as the dependent variable. The independent variables for the corn model were the beginning world stock level, world utilization and world production. For the corn model the data were for the 1975/76 crop year (ending stock levels for the 1973/74 crop were not available) through 1985/86. The corn price equation chosen as the best for prediction purposes was:

$$\ln Pc' = \underset{(15.88)}{6.05565} - \underset{(-2.66)}{.00604}\ SBc + \underset{(1.67)}{.00366}\ Uc - \underset{(-3.68)}{.00509}\ PDc \quad (2)$$

where: Pc' = average marketing year price of corn in Rotterdam, U.S. dollars per metric ton, adjusted for inflation by dividing by the U.S. GNP deflator (1985-86 = 100).

SBc = beginning world marketing year stocks of corn, millions of metric tons.

Uc = world marketing year utilization of corn, millions of metric tons.

PDc = world marketing year production of corn, millions of metric tons.

ln = natural logarithm

The t-values in paratheses below estimated parameters indicate that the estimated stock coefficient is significant at the .02 level, the production coefficient significant at the .01 level, and the utilization coefficient significant at the .07 level. The model R^2 was .822. The average annual percent error for the model was 1.2%.

Levels of corn price responsiveness at mean, low and high observed values for the variables are listed in Table 2. The partial derivative of the stock variable at the mean with respect to price, $\partial Pc'/\partial SBc$ = - .00604(Pc'), is - .00604 (168.09) = -1.02. This indicates that at mean levels of production and use, for every one million metric ton change (increase) in beginning world stocks the price of corn will change (decrease) by $1.02 per metric ton. At the mean world production of corn, a one million metric ton change (increase) in corn consumption changes (increases) the price of corn by $.62 per metric ton. The price of corn appears to be most flexible to changes in stocks. For the stock variable the price flexibility at the mean is $\partial Pc'/\partial SBc\ (SBc/Pc')$ where SBc and Pc' are taken at their mean values; -1.02 (53.9/168.09) = - .33%. This indicates that for a one percent change (increase) in the world stock levels of corn the price of corn will change (decrease) by .33% at the mean. The other price flexibilities in Table 2 were calculated similarly.

Table 2. Measures of Price Responsiveness for Corn.

Variable (X)	Levels of Variables (Xi)	Corresponding Price[1]	(∂Pc/ ∂Xi)	Price Flexi-bility
	million metric tons	- - $/metric ton - -		%
Stocks	28.6 (low)	195.85	-1.18	- .17
	53.9 (mean)	168.09	-1.02	- .33
	106.6 (high)	122.27	.74	- .65
Utilization	326 (low)	130.58	.48	1.20
	395 (mean)	168.09	.62	1.46
	437 (high)	196.03	.72	1.61
Production	328 (low)	247.12	-1.26	-1.67
	403 (mean)	168.09	- .86	-2.06
	482 (high)	112.44	.57	-2.44

[1]Assuming other variables at mean levels.

USING THE MODELS

To use the models for short-run prediction purposes, projected current-year production and utilization levels are needed. The Foreign Agricultural Service, U.S.D.A. publishes estimated world production and utilization levels for both wheat and corn for the current and upcoming crop years. Use of the models for forecasting prices is illustrated below.

For forecasting the 1986/87 marketing year prices for wheat and corn the models used the following estimates from U.S.D.A. (Sept. 1986) in equations (1) and (2):

Variables	Wheat	Corn
	- mil. of metric tons -	
BEGINNING STOCKS (SB)	123.5	121.4
UTILIZATION (U)	505.9	444.0
PRODUCTION (PD)	505.6	477.0

For wheat, Pw = -1004.0 - 177.04 (ln 123.5) + 936.83 (ln 505.9) - 610.43 (ln 505.6) = $175.97 per metric ton. Thus, as of September, 1986, the model would have suggested a marketing year price of $175.97 per metric ton for 1986/87, a 5.6% increase from the $166.68 price for 1985/86. However, with 1986/87 estimates of stock, production, and use levels as of August, 1987, the model estimate was $153.18 per ton. These compare to an actual price of $135.40 per ton (U.S.D.A., Aug. 1987).

For corn, ln Pc' = 6.05565 - .00604 (121.4) + .00366 (444) 1986/87 GNP deflator increase of 2% (U.S.D.A., June 1985), then estimated Pc becomes $91.79 (1.02) = $93.63. Forecasts as of August, 1987 gave a price estimate of Pc = $89.62. The actual Pc for the first 9 months of the 1986/87 marketing year was $75.57.

SUMMARY AND CONCLUSIONS

Many variables affect prices of agricultural commodities and no model can forecast prices without error. The models developed in this study consider major supply and demand factors in estimating prices of wheat and corn. They are simple enough to be usable without sophisticated computer equipment, e.g., Lotus 1-2-3 (Lotus Development Corp.), and needed data are published on a regular basis and are readily accessible. Larger, more complex models could have been estimated that might have been more accurate, but they would have been more difficult to use.

The models are sufficiently reliable to facilitate general forward planning decisions by producers, agribusiness firms and merchants who need a basis for price expectations six to nine months in advance. The wheat model averaged 6.6% error when the model was used to predict the prices for the last 12 crop years. The largest error was 22.9% in 1977/78. The corn model was slightly more accurate, averaging only 1.2% error over the last 11 crop years. The error in the models should be considered when using the models to forecast prices. Forecasted prices for 1986/87 using the USDA world production and use estimates as of August, 1986, were about $94 per metric ton for corn, down 20% from the 1985/86 price, and about $176 per metric ton for wheat, 6% above the 1985/86 price. The prices obtained from the models should be looked at as a general level of prices for the next crop year, not as an exact forecasted price for any one date. Consequently, forecasted prices might be expanded to a range of plus or minus seven or eight percent.

The price flexibilities obtained from the models indicate that the price of corn is less responsive to changes in stock levels than is the price of wheat. The price of wheat is more responsive (has higher absolute value of price flexibilities) to production and utilization than the price of corn. The price of wheat is most responsive to changes in the utilization of wheat and least responsive to changes in stocks of wheat. The price of corn is most responsive to changes in the production levels of corn and least responsive to changes in stock levels of corn.

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