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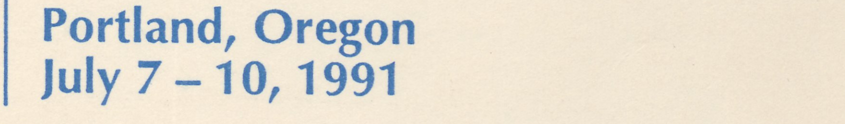

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Wheat Price Determinants

Abstract

Variability both for wheat prices on average and also between classes has been of great concern to farmers in recent years. Using cross-sectional data, relative wheat prices by class are estimated using own-class stocks-to-use ratios and grain quality characteristics.

Introduction

Considerable concern over the level and variability of wheat prices have been voiced by farmers over the last few years. Farm level wheat price averaged $3.72 per bushel during the 1988/89 and 1989/90 crop years. However, an near record U.S. crop as well as bumper crops in other major wheat-producing countries drove U.S. farm-level wheat prices down to less than $2.50 per bushel in September 1990. While some farm groups were concerned with overall wheat prices, others believed that prices for specific classes of wheat were being adversely affected by unfair competition from subsidizing exporters. This analysis is designed to determine what drives relative prices for the various wheat classes, and attempts to derive a model to predict those differentials in the future.

Wheat is grown throughout the United States under a variety of weather and soil conditions. In addition, wheat has two distinct growing seasons. Winter wheat is sown in the fall and harvested during the following spring or summer, while spring wheat is sown in the spring and harvested in the late summer or early fall. Unlike most other crops, five major classes of wheat are grown in the United States: hard red winter (HRW), soft red winter (SRW), hard red spring (HRS), white and durum. These classes are grown in distinct regions and have different end uses. The production areas for the various classes occasionally overlap, such as the HRS and durum areas in North Dakota.

Although there is some substitution between classes, the flours produced have different end uses. HRW, the largest class, is used for bread wheat or to produce all purpose flour. HRS is also an excellent bread wheat. Its higher protein content allows it to be mixed with "weaker" wheats for bread flour. SRW flour is used for cakes, pastries, and crackers. White wheat flour is used for noodles and durum flour is used primarily for pasta products.

Classes provide broad indicators of the usefulness of a particular wheat. However, growing conditions can also affect the end-use characteristics of wheat. In drier years when yields tend to be lower, the protein content of wheat increases. This allows millers, for example, to substitute between HRS and HRW. In other years the percentage content of factors such as dockage and foreign material tend to be higher. These sorts of departures may occur in localized areas or they may occur regionally.

In the current domestic market, premiums or discounts are applied for all variations in grain quality as determined by official grading standards (such as test weight and damaged kernels), as well as for other factors that domestic users view as important. These pricing schedules change with different market conditions, and provide information to both producers and users as to what grain characteristics are valued in the market.

Concerns about grain quality and lack of grain uniformity, particularly that shipped to foreign purchasers, prompted inclusion of a Grain Quality Title in the Food, Agriculture, Conservation, and Trade Act of 1990 (1990 Farm Bill). Among other provisions, the title requires that grade-determining factors be consistent with intermediate and end-use performance goals and establishes minimum quality standards for grain entered into CCC programs. These efforts are aimed at providing better information to potential buyers about the quality of grain they receive both from commercial channels and concessionary sales.

Economics of Grain Characteristics

The economic effects of grain characteristics will be illustrated using a simple supply and demand model. The quantity of grain demanded on period i (Qd_i) depends on the price (P_i) and characteristics ($CHAR_i$) of the grain (**Equation 1**).

1) $Qd_i = f(P_i, CHAR_i)$

The characteristics of the wheat represent a variety of factors that influence value. The grain quality characteristics can be defined by numeric factors such as protein content, dockage, test weight, total defects, and foreign material. The quantity of wheat demanded at a given price depends on how the market values the characteristics at a point in time. All other things equal, we expect that grain buyers would be willing to pay a higher price for grain exhibiting higher valued characteristics. Using standard economic theory, we assume diminishing marginal returns to grain quality.

The quantity of grain supplied in period i (Qs_i) depends on the current price, characteristics of the grain, and any carryover of grain stocks from the previous time period (**Equation 2**).

2) $Qs_i = f(P_i, CHAR_i, S_{i-1})$

To supply grain with higher-valued attributes requires increased production costs or switching to lower yielding varieties, thus effectively shifting the supply curve so that less grain would be supplied at any given price. The characteristics variables refer to changes in average quality and abstract from weather-induced quality differences that might occur. The model as presented does not explicitly allow for changes in government policy instruments, such as acreage set-asides, loan rates and target prices, that may also influence supply.

The market clears and the model closes at the price where the quantity supplied minus any stocks held over for future use equals the quantity demanded (**Equation 3**).

3) $S_i = Qs_i - Qd_i$

Assume that the government decrees that grain quality must be improved to $CHAR^* > CHAR$. Presumably since quality improved, grain buyers will be willing to purchase more grain at a fixed price. However, since grain quality improvement has a cost, suppliers will only be willing to supply the same quantity of grain (but higher quality) at a higher price. If producers cannot meet the quality standards at a reasonable cost (the equilibrium market for the higher quality), total grain production will decline. On the other hand, the higher price may induce higher production if is sufficient to cover the increased costs of production. Thus, the equilibrium price of grain will increase, while the net effect on the quantity of grain marketed, which depends on the relative supply and demand elasticities, is indeterminate. Larue and Lapan suggest that export demand will increase with higher grain quality only when export demand is elastic.

When total grain supplies are tight purchasers are less likely to distinguish between grain sources based on quality than when supplies are abundant. In other words, the elasticity of demand with respect to quality increases at higher levels of grain use. Thus, if a country has the reputation of supplying poor quality grain, total grain exports may not be affected when worldwide supplies are tight. However, when stocks are large, quality may be the key factor in a sale. In periods with large supply, countries with low quality grains would tend to build stocks and incur grain storage costs, or be compelled to remove land from production or use costly export subsidies.

The empirical model used in this in this analysis includes characteristics that are believed to influence wheat prices by class in the United States from 1986/87 through the 1989/90 marketing years. The empirical model (**Equation 4**) is expressed as:

4) $PRICE_{ics} = f(S/U_{ic}, CHAR_{icgs})$

The price variable ($PRICE_{ics}$) is represented as the difference between the average farm price received and the loan rate for the i-th year, the c-th class of wheat, the s-th state. The stocks-to-use by class in the current year is included to account for shortages and surpluses of a given class. The model aggregates influences on price of changes occurring both in the supply of and demand for a particular wheat class in a given year, in a reduced form equation. For convenience of estimation, the reduced form equation is estimated in price-dependent form. Finally, a set of variables are included to measure differences in quality.

<u>Data and Variables</u>

This study was conducted over the period 1986-89. The data on grain quality was derived from the New Crop Survey that is collected by the Federal Grain Inspection Service annually. The survey reports on quality characteristics of wheat that was officially inspected within a month of the beginning of harvest in each wheat-producing state. Individual observations within the data set represent more than 58,000 samples. For this analysis, mean values for the relevant variables were derived from the data set for every stratum as defined by state, wheat class, and U.S. official grade. The quality factors that were utilized as independent variables in this analysis were dockage content, test weight, total defects, and protein content for the hard wheat classes. Data on additional grade-determining factors were also available but not utilized because of extreme collinearity with variables used in the model.

State-level prices used in the analysis were reported in the USDA publication Agricultural Prices. For states in which more than one class of wheat per season is grown, (e.g., both HRW and SRW in Missouri), the price used for the minor class was approximated by multiplying a ratio of national prices for the two classes with the price for the dominant class in that state. All prices used in the analysis were subtracted from the wheat loan rate. The stocks-to-use variables by class were drawn from the Wheat Situation and Outlook Report. The variable calculated was the annual ratio for a particular wheat class of the stock to total use (domestic and exports).[1]

Empirical Results

The system of price functions by wheat class reported in this study was estimated by the Seemingly Unrelated Regression (SURE) technique. The same system was also estimated with 3SLS and LIML estimation techniques but did not perform nearly as well with those econometric methods. All equations exhibited extreme serial correlation, as would be expected from this type of data, so all were estimated with 1-period autoregressive coefficients. The results of the estimation are reported in table 1.

All equations had R^2's which were above 0.67, which are robust results for an estimation using a panel-type data series. The magnitude of the autoregressive coefficients was similarly large in all equations, suggesting that market prices are transmitted both temporally and regionally in a similar manner for all wheat classes.

The individual coefficients in the various price functions also tell a fairly consistent story. Because of the physical nature of grain, quality characteristics of that grain tend to be multicollinear, and the equations were extremely sensitive to choice of variables. As predicted, the stocks-to-use ratios in each class, representing tightness of the market in that particular year, had a negative coefficient in 3 of the 5 equations. The coefficients were nonsignificant in the SRW and HRS equations.

Test weight and total defects are grade-determining factors in U.S. official standards, and dockage is reported on grading certificates and often is seen as a key quality factor in contracts negotiated by both domestic millers and foreign users.

The coefficient for test weight was positive and highly significant in all equations. Test weight generally functions as a proxy for the density of the grain, and the denser the grain is, the more usable material millers may obtain from it. The coefficient for total defects, another grade-determining factor, was negative in the SRW, White and Durum wheat equations and positive and statistically significant in the Hard wheat equations. The negative results are according to expectation, as wheat with a high proportion of total defects is more difficult to process and also yields less high-quality products. The positive coefficients in the Hard wheat price equations are harder to explain. The distribution of total defects in the Hard wheat data are somewhat unusual, which may have caused the contrary coefficient sign. More than three-fourths of the observations would meet Grade No. 2 requirements based on

[1] An all-wheat stocks-to-use variable was also tested in the equations, but did not perform as expected.

Table 1--Estimates of wheat price functions, by class, 1986-89

Variable	Hard Red Winter	Soft Red Winter	Hard Red Spring	Durum	White
Intercept	-2.048* (-17.21)	-1.79* (-14.72)	-2.26* (-23.99)	-2.132* (-20.33)	-1.047* (-24.28)
Stocks-to-use	-1.318* (-4.66)	0.219 (0.25)	0.504 (0.60)	-1.906* (-3.47)	-3.073* (-7.98)
Dockage	-0.091* (-2.80)	0.132* (3.78)	0.061 (1.41)	-0.084 (-1.39)	-0.046 (-1.57)
Test Weight	0.035* (3.97)	0.032* (11.73)	0.020* (2.25)	0.058* (9.42)	0.055* (15.03)
Total Defects	0.033* (2.87)	-0.0028 (-0.31)	0.027* (2.25)	-0.034* (-2.57)	-0.005 (-0.38)
Drought	0.269 (1.39)	-0.257 (-1.11)	0.334* (2.14)	-0.159 (-0.79)	0.0942 (0.58)
Protein	0.010 (0.26)	-----	0.023 (0.59)	-----	-----
AR	0.769* (23.16)	0.738* (21.91)	0.704* (18.78)	0.654* (17.68)	0.596* (16.42)
R^2	0.730	0.758	0.754	0.677	0.734
N	338	257	235	157	134

Note: All prices are the differential between class-specific price and wheat loan rate.
T-statistics in parentheses.
* indicates coefficient is statistically significant at 10 percent confidence level.

Source: New Crop Survey, 1986-89, Federal Grain Inspection Service, USDA.

the total defects factor alone, but there are several observations with high total defects, which skewed the sample mean.

The results were somewhat mixed for the dockage variable. The coefficient was negative in the HRW, Durum, and White wheat price functions, and positive in the SRW and HRS wheat functions. High dockage is generally regarded as detracting from wheat quality. When dockage levels are mentioned in contracts, high levels are penalized. Thus, the expected sign is negative. For the two equations in which the coefficient's sign was positive, it is possible that discounts for other factors (i.e. high total defects for HRS wheat, and low test weight for SRW wheat) overwhelmed any discounts or deductions for dockage, which was not a major problem for these classes.

A dummy variable for the occurrence of a drought during growing season was also included. The coefficient of this variable was positive in three equations (HRW, HRS, and White wheat), and negative in the other equations.

Protein content appears only in the price equations for the Hard wheat classes. This variable is important primarily in the Hard wheat classes, whose users prize protein for bread-making. The signs on both coefficients are positive, but not statistically significant. As a rule, protein content above 11 percent in hard wheats receive premiums, but may well be discounted on net if wheat with protein content above 15 percent also has low test weight, high total defects, etc. If we were able to break down prices by grade more finely, we would certainly expect to find that all other factors equivalent, wheat shipments with higher protein receive a premium. Price data to that level of refinement, however, are not available for this analysis to confirm this hypothesis.

Implications

This study was designed to examine the extent to which the market rewards or penalizes farmers for changes in grain quality. The estimated model can also be used to analyze price differences between different wheat classes. Throughout most of the 1989/90 marketing year durum producers complained that durum prices were too low relative to HRS prices. The General Accounting Office (1989) conducted an analysis of relative prices, and using a stocks/use model they predicted higher durum prices than were being observed in the marketplace. Adjusting for quality differences in 1988/89 and 1989/90 for HRS and durum, our model shows that durum prices should have been approximately $.09/bushel higher than HRS in 1988/89, while HRS prices should have been $.02/bushel higher than durum prices in 1989/90. Actual durum prices in 1988/89 averaged considerably higher than HRS prices, while the reverse occurred in 1989/90.

The model in this study could provide an indication of the benefits in a partial equilibrium sense of gains to farmers from grain quality improvement. The estimated results from this study provide an indication of the benefits in a partial equilibrium sense of gains to farmers from grain quality improvement. In a recent study, Mercier and Young estimated that the costs to grain exporters of combining dockage and foreign material into a single grading factor for wheat range between $19.9 and $22.27 million for the 1987/88 marketing year. Using the model presented in table 1, it would be possible to estimate returns to farmers from providing quality improvements, although not done in this analysis. Of course the model cannot be disaggregated to yield a supply elasticity to indicate the costs of farmers to provide higher quality grain to the market. The analysis indicates what the marketplace is paying for the quality of delivered grain.

Summary

This paper addresses some of the economic effects of changes in grain quality. A simple supply and demand model is developed to illustrate the effects of changes in grain quality on grain demand, stocks, and prices.

The model was estimated to explain relative wheat prices by class. Three quality factors, test weight, total defects, and dockage, were also included in the estimated equations. Most of the estimated coefficients had the expected signs and were statistically significant.

This analysis found that the wheat market does transmit information on grain quality differences as well as general supply and demand factors into prices received by farmers. What this analysis cannot fully address is the relative strength of the market signals regarding quality differentials. Can market signals be sufficiently strengthened to increase the demand for U.S. wheat in order to offset the costs to farmers of better grain quality?

Wheat prices move in response to changes in supply and demand. The United States produces a wide variety of wheats with somewhat different intrinsic characteristics each year. Differences in the wheat characteristics also play a strong role in determining price levels.

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