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FUNDAMENTAL FACTORS DETERMINING THE PRICE SPREAD BETWEEN HARD RED AND SOFT RED WINTER WHEAT

Kevin P. McNew, *Oklahoma State University*

Abstract

Price differences (spreads) among hard and soft red winter wheat fluctuate from year to year. These price spreads lead to producer decision for certain growing regions on which product to produce for a given year. Least squares regression and correlation procedures were used to determine what attributes of supply and use for each class of wheat were good predictors of the price spread. The most important factor on a one variable basis was soft red winter wheat production. In the multiple variable situation, soft red production and hard red production were the most important in determining the price spread.

INTRODUCTION

Changing government programs, uncertain yields, and fluctuating export demand have contributed to wheat price variability. This variation rose significantly in the early seventies but has stabilized in the eighties (Updaw). With continuing wheat price uncertainty, it become important for producers, policymakers, and agri-business related industries to better understand how supply and use in a market lead to price deviations in wheat.

In the United States, five classes of wheat are produced: hard red spring, hard red winter, soft red winter, durum, and white. Due to their relatively high protein levels, the two winter wheat classes comprise the basic ingredients in bread flour. Soft red winter (SRW) wheat commonly has a lower protein percentage, therefore, its primary use is for cakes, cookies and cereal products. The growing region for SRW wheat is in the eastern portion of the United States. Hard red winter (HRW) wheat has a higher protein percentage than SRW and is primarily grown in the central plains and the eastern portion of the rockies (Canada Grain Council).

The growing region between the two products overlaps in eastern Kansas and western Missouri, allowing for producer-decisions of which wheat class to produce. Because both products are winter variety and production practices for the two types are essentially the same, there is not major changes in enterprise structure that would limit the producer in this region to produce either the hard or soft red winter wheat variety. Producers are able to base production decisions on projected price differentials between the two products for any year assuming the yield of the two classes to be the same.

Price spreads between hard and soft red winter wheat usually exist and are attributed to supply and use of the products during a given time period. The price spread varies in size from year to year depending upon the fundamental factors in the wheat market. The variability of the price spread has important implications for all entities of the grain business. In the past 18 years, the price spread has been as high as $0.62/bushel premium HRW and as low as $0.33/bushel discount HRW (Economic Research Service). With the government playing an integral part in production agriculture, this price spread could be directly caused by government programs. However, in this paper there will not be a variable attributed to government programs because government intervention will be accounted for in the data used.

In 1974, HRW wheat production was 85.6 percent of all winter wheat produced, while in 1982 it was as low as 62.2 percent. Not only has production of HRW lost market share, but also exports of HRW wheat have lost the market share over time. This is due primarily to the production of SRW increasing with respect to HRW. In 1974, HRW wheat exports accounted for 96.6 percent of winter wheat exports, while in 1982 exports of HRW wheat were 62.1 percent (Economic Research Service).

Bale, Ryan and Wilson have investigated the topic of price spread among different wheat classes. Most of these studies were conducted assuming that wheat is a homogeneous product while also incorporating the use of protein percentage as a determinant in price spread. Between the two classes of wheat, HRW has a greater protein percentage than SRW. Therefore, if protein percentage was the only determinant of price spread, then HRW would always sell at a premium to SRW, However, in this paper the assumption is that the two products are not homogeneous because of their different uses and milling characteristics. Therefore, protein percentage will be assumed to be a non-determinant in the price spread model.

The objectives this study are to:

1) determine what fundamental factors are integral in developing the price spread between hard and soft red winter wheat.

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2) develop a model with limited independent variables and capable of predicting this price spread.
3) determine the equilibrium production levels for which HRW has the same price as SRW.

THEORY OF PROBLEM

This problem will constitute the combining of the supply and demand factors for HRW wheat and SRW wheat. As stated earlier, the wide displacement of protein percentage in the two products accounts for the heterogeneity of the two classes of wheat. Many factors interact among the market place to determine the prices set for the two classes. For each class of wheat, a price dependent equation can be developed using production, domestic use, exports and beginning stocks for the corresponding product as independent variables. Thus, prices of the two products may be expressed as follows:

$$P_H = F(Q_H, D_H, E_H, S_H) \quad (1)$$

$$P_S = F(Q_S, D_S, E_S, S_S) \quad (2)$$

where P_H and P_S are the price variables in dollars for hard and soft red winter wheat. Q, D, E, and S represent the quantity supplied, quantity for domestic use, exports, and beginning stocks, in million bushel units, respectively. To obtain a difference equation, one could subtract the two equations from each other and group like terms; however, because heterogeneity has been assumed, this would be unacceptable because the terms in the equation are not the same. However, a new equation can be developed from these data by combining the independent variables in both equations and conducting a multiple regression analysis. The resulting equation may be expressed:

$$P_D = P_H - P_S = f(Q_H, Q_S, D_H, D_S, E_H, E_S, S_H, S_S) \quad (3)$$

where the variables are the same as in *(1)* and *(2)* and P_D is the difference in the prices of hard and soft red winter wheat.

The basic problem associated with such a multi-variable equation is that the estimated parameters will usually have low test statistic values; thus, fitting all the variables into the equation becomes difficult. To address this problem, an equation will be developed using two alternative steps: 1) look at all possible variable combinations to determine the best fit by eliminating those variables with low Type III sum of squares, and 2) develop a percentage variable that combines the production of both hard and soft red winter wheat that will have a high R-square value and a high test statistic, thus simplifying the prediction process.

DATA SOURCES

All data were collected from the *U.S. Wheat and Situation Outlook Report* for the marketing years of 1971-1988. The data used are annual and prices are simple averages of monthly prices.

ANALYSIS OF PROBLEM

The first step in the analysis was to evaluate all possible combinations of independent variables from equation *(3)* and determine the R-square value and the Type III sum of squares for all combinations. By looking at the Type III sum of squares, it can be determined which variables add the least to the regression sum of squares, and thus be deleted from the model.

By using SAS computer system and PROC STEPWISE procedure, the best possible outcomes were determined on the criterion of a large R-square measurement. The results of the analysis are presented in Table 1.

According to the analysis, as more independent variables are added, an increase occurs in the R-square value. However, in general, as more variables are added to a model, there is an increase in the number of parameter estimates that are not significant at the 10 percent level. Therefore, the procedure was ended after four variables were in the model. In the one variable equation, SRW wheat production is the best predictor of the price spread with an R-square of .836 and a significant test statistic. This can also be illustrated by looking at the simple correlations in Table 2. By looking at the price difference column, we observe that SRW wheat production is highly correlated t to the price difference. Also, all SRW wheat variables are more highly correlated to the price difference than their HRW wheat counterparts. However, results from the correlation table contradict those obtained from performing a best-fit multiple regression. By looking back at Table 1, it can be observed that the best fit equations are determined by adding the HRW wheat variables. This contradiction can be explained by looking at the procedure of analysis. In correlation analysis the variables are correlated on a one-to-one basis; while in regression, variables are analyzed as a group to determine the effect. In t this situation, there is obvious appearance of multicollinearity, or the correlation among the independent variables.

The second step in the analysis was to derive a production percentage for hard and soft red winter wheat to determine the equilibrium price level for which HRW price is equal to SRW price. Production percentages for SRW wheat (PRODS) and HRW wheat (PRODH) were obtained as:

$$PRODS = \frac{Q_S}{Q_H + Q_S}$$

and

$$PRODH = \frac{Q_H}{Q_H + Q_S}$$

because these two variables are percentages based on total production of the two products, their sum equals one. That is,

$$PRODH + PRODS = 1$$

A simple linear regression procedure can be performed using each of these two new variables as independent variables:

$$P_D = \beta_{0H} + \beta_{1H} * PRODH$$
$$P_D = \beta_{0S} + \beta_{1S} * PRODS$$

where β_0 *and* β_1 are the intercept and slope estimates for each equation.

These two equations will allow prediction of the price spread at variable levels of production percentages for the two types of wheat. By obtaining these two equations, we can determine the maximum price differences under two conditions. The first condition assumes that HRW wheat production increases relative to soft.

$$\lim_{PRODH \to 1} P_D = \beta_{0H} + \beta_{1H}$$

and

$$\lim_{PRODH \to 0} P_D = \beta_{0H}$$

Therefore,

$$\beta_{1S} = \beta_{0H} - \beta_{0S}$$

Then by adding the two parameters together, we obtain:

$$\beta_{1S} + \beta_{1H} = \beta_{0H} - \beta_{0S} + \beta_{0S} - \beta_{0H} = 0$$

Therefore, $\beta_{1S} = -\beta_{1H}$, thus giving an exact inverse relation between the two slopes.

With these two equations, we can now determine the equilibrium condition for which P_D is equal to zero or in the case where the relative production percentages make the two product prices equal to each other.

Upon performing the analysis, we obtain the following estimates:

β_{0H} = 3.133 β_{0S} = -0.911

β_{1H} = -4.045 β_{1S} = 4.045

These estimates resulted in a R-square value of 87.9 percent, an F-statistic of 116.69 and a mean square error of .006. With these estimates the equilibrium production percentage for HRW wheat with relation to soft red winter wheat is 77.5 percent. If HRW wheat exceeds this production percentage, then SRW wheat's price will exceed HRW wheat's price. The reverse is also true, if HRW wheat production decreases below 77.5 percent, then HRW wheat's price should exceed SRW wheat's price. Table 3 shows this analysis performed on the last 18 years of data. As observed, this model was able to predict the appropriate sign for all 18 observations. This model can be compared to the two-variable model from Table 1 which uses SRW and HRW production to predict the price spread. Table 4 represents the fitting of the two-variable model to the 18 observations. This model is able to predict the appropriate sign for 17 of the 18 data points. This model has an R-square of .876 and a mean square error of .007. For the purpose of predicting the price spread, the model using production percentages is the preferred model because of the higher R-square and lower mean square error value.

RESULTS OF PROBLEM

With the analysis done, we determine that on a one-to-one basis the fundamental factors of SRW wheat are a better determination of the pricespread than HRW wheat production. However, with the grouping of the variables we determine that HRW wheat factors along with the SRW wheat production make a good model for prediction. The four variable model in Table 1 shows that soft wheat production along with hard wheat beginning stocks, domestic use and exports account for 90 percent of the variability in the price spread.

This analysis reveals two significant factors in the price spread determination problem. The first is that because production factors between the classes are the major determinants of the price spread, producers are unable to determine which class of wheat to produce prior to planting. Secondly, the analysis suggests that information prior to planting, more specifically beginning stock levels, has no bearing on the price spread for the two products in the marketing year.

SUMMARY

In eastern Kansas and western Missouri wheat producers must make a production decision upon which

class of wheat to produce for a given year. Prior to the production period, the producer must draw upon information that will allow him to make a choice on wheat class. However, from the analysis performed, the factors that are most important in determining the price spread between hard and soft red winter wheat are the production factors of the two classes.

With production variables as the key factors in the price spread model, it was also of interest to determine the equilibrium production levels that make the price of the two product prices the same. When HRW wheat production is more than 77.5 percent of total winter wheat production then the price of SRW wheat will be greater than HRW. The reverse scenario is also true when HRW production percentage falls below the 77.5 percent level, thus making HRW wheat price more than SRW wheat.

Table 1. Parameter Estimates and R-Square Values for Dependent Variable PDIF.

Dependent Variables	Parameter Estimate	R-square
SPROD	.0014	.836
SPROD	.0018	.876
HPROD	.0004	
SPROD	.0015	.882
HDOM	.0004	
HEXP	-.0003	
HBEG	.0003[1]	.903
SPROD	.0016	
HDOM	-.0012	
HEXP	-.0004	

[1]Parameter estimate not significant at the 10 percent level.

Table 2. Correlations for All HRW and SRW Fundamental Factors.

	PDIF	HBEG	SBEG	HPROD	SPROD	HDOM	SDOM	HEXP	SEXP
PDIF	1.00	0.08	0.23	0.61	0.91	0.00	0.59	0.22	0.86
HBEG	0.08	1.00	0.75	0.23	0.20	0.88	0.57	0.12	0.08
SBEG	0.25	0.75	1.00	0.45	0.35	0.69	0.55	0.16	0.27
HPROD	0.61	0.23	0.45	1.00	0.79	0.31	0.63	0.37	0.71
SPROD	0.91	0.20	0.35	0.79	1.00	0.16	0.68	0.38	0.96
HDOM	0.00	0.88	0.69	0.31	0.16	1.00	0.56	-0.13	0.01
SDOM	0.59	0.57	0.55	0.63	0.68	0.56	1.00	0.29	0.45
HEXP	0.22	0.12	0.16	0.37	0.37	-0.13	0.29	1.00	0.38
SEXP	0.87	0.08	0.27	0.72	0.96	0.01	0.45	0.38	1.00

Table 3. HRW Production Percentage Related to Observed and Expected Price Difference.

Year	HRW Prod[1] %	Observed PDIF	Expected PDIF
1971	81	-0.11	-0.15
1972	78	-0.01	-0.02
1973	77	0.03	0.01
1974	86	-0.33	-0.33
1975	75	0.04	0.09
1976	75	0.20	0.08
1977	74	0.07	0.16
1978	74	0.16	0.14
1979	81	-0.19	-0.12
1980	77	0.01	0.01
1981	73	0.12	0.18
1982	62	0.53	0.61
1983	68	0.62	0.38
1984	70	0.28	0.29
1985	70	0.23	0.29
1986	77	0.06	0.02
1987	78	-0.04	-0.01
1988	75	0.07	0.12

[1]Observations with identical production percentages may not have the same expected value due to rounding error.

Table 4. Regression Analysis pf PDIF Variable with HPROD and SPROD as Independent Variables.

Year	HPROD	SPROD	Observed PDIF	Expected PDIF
1971	755	174	-0.11	-0.12
1972	748	212	-0.01	-0.05
1973	762	226	0.03	-0.03
1974	961	161	-0.33	-0.22
1975	879	288	0.04	0.04
1976	1053	343	0.20	0.07
1977	968	348	0.07	0.11
1978	992	350	0.16	0.10
1979	836	202	-0.19	-0.10
1980	1093	321	0.01	0.01
1981	1181	435	0.12	0.18
1982	1117	676	0.53	0.64
1983	1255	590	0.62	0.43
1984	1198	504	0.28	0.30
1985	1251	531	0.23	0.33
1986	1230	368	0.06	0.04
1987	1018	292	-0.04	-0.01
1988	1019	348	0.07	0.09

[1]Production variables are in million bushel units.

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