Increasing U.S. Hard Red Winter Wheat Competitiveness in Latin American Markets

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Background

The United States leadership in wheat exports has faced growing competition and some competitive disadvantages in recent years. Countries such as Canada, Australia, Argentina, European Union (EU), and the Former Soviet Union (FSU) are growing contenders for world wheat market share (USDA). To stay competitive, the U.S. must find a way to improve, trace, and market the value of its wheat to better satisfy the needs of its customers. One widely-recognized hurdle for improving the market value of U.S. wheat is ensuring the consistency of end-use quality attributes to foreign buyers.

Canada, the main competitor for U.S. wheat, maintains greater centralized control over the production, grading, loading/shipping, cleaning, and marketing of wheat varieties. Conversely, the greater wheat variety selection in the U.S. is based upon a broader set of market pressures and incentives, and even institutional evaluation. Also, differentiations based on the U.S. grading system are too general and in most cases do not account for specific buyers' preferences and requirements.

Quality differences play a role in pricedifferences. These differences are cumulative effects of the production/marketing system. Characteristics such as color, protein level and quality, strength and hardness may be significantly different among countries and are in large part due to varying environmental conditions and agronomic practices. Wheat price is a function of the implicit value of characteristics, most commonly those easily observed or documented: protein level (quantity, not quality), class of wheat, visible defects, and country of origin are among the most easily identified characteristics. Better understanding of implicit values would clarify how production/marketing policies affect the price of the product (Dahl, Wilson, and Johnson 2000, 2003).

Dahl, Wilson, and Johnson identified imperfection in wheat markets as a result of the lack of information related to wheat quality and consistency. A perfect market should be characterized by buyers being specific about the attributes they want and paying premiums for them: "price signals transmitted from buyers to sellers would convey information about attribute values." However, the wheat market presents "informational uncertainties": growers are unsure about what buyers demand and what they are willing to pay for it. Functional characteristics desired by end-users are not measured in the grain marketing system because of time, cost and repeatability. Only easy-to-measure characteristics are captured and market premiums and discounts are established for those. Thus, the associated premiums and discounts result in limited information to wheat breeders because they are unstable, they vary by contract (i.e. different buyers have different end-product expectations), and this information is not generally available to the end-user.

Objective

This study attempts to estimate the significance of the attributes related with end-use functionality on the prices for hard red winter (HRW) wheat. A hedonic pricing model was used to explain the variations in price basis values due to attributes relevant to both grain grades/standards and end-use functionality. The price basis represents the difference between the local cash price for a set of Oklahoma elevators and the futures contract price of Kansas City Board of Trade (KCBT). It was assumed that the differences in the wheat quality attributes across the different elevator locations would have an impact on the differences in price basis.

Review of Literature

In 2000, Wilson, Dahl, and Johnson analyzed costs and risks associated with different wheat procurement strategies. They used a model with statistical and geographical distribution for hard red spring wheat industry and end-use requirements. End-use quality was treated as a random variable, related to cost of information, moral hazard and adverse selection. The buyer was assumed to be imperfectly informed about quality and the seller was assumed to have imperfect information about buyer's use of the product. Wheat was considered an experience good, because the end-quality is known after purchasing.

End-use quality characteristics are difficult to predict based on measurable grain qualities. For hard wheat, Wilson, Dahl, and Johnson protein content and locations are proxies for desirable end-use characteristics. Some wheat buyers specify grade factors and protein in their purchases. Other wheat buyers specify grade factors and protein in their purchases. In other cases, a leading flour milling company indicated that an integral part of its future strategy would involve producing specific varieties under contract for handling and processing within their system. An alternative strategy would be to evaluate wheat and flour based on samples collected through the harvest season. After testing, the information can be used to target locations for procurement.

In 1999, Dahl and Wilson found that the value of wheat to the miller is affected by a number of factors beyond the base price. Dockage, foreign material, shrunken and broken kernels, and moisture content affect the value of a lot of wheat to millers by increasing shipment costs, reducing the amount of millable material purchased, and increasing the amount of by-products produced. They developed an alternative way to calculate the value of wheat to millers that consider the effect of differences in quality factors. The model includes buying on a “net wheat” price, based on a millable wheat index and net profit in milling.

Wheat buyers determine the value of wheat independent of the moisture content and screenings captured in the grading process. Derivation of “net wheat” price is a method to remove these effects and provide a more appropriate estimate of the value of wheat to the miller. The millable wheat index considers the amount of non-millable material and moisture content of wheat and derives a measure which can be multiplied by the price of wheat to determine the value of a wheat lot after it is ready for milling. Evaluation methods assume that the quality parameters are known.

In practice quality parameters are unknown, with certainty. They can be represented by distributions. In the Dahl-Wilson model valuation formulations are estimated using a Monte Carlo simulation. Distributions of quality characteristics were estimated from export shipment data for individual quality characteristics. Each of the valuation formulations was simulated using the distributions estimated as an indicator of variability for individual quality characteristics. The model allowed comparisons of the impact of variability in quality characteristics on the value of wheat to millers.

In 1994, Uri et. al. examined whether the grain quality factors contemplated by the Federal Grain Inspection Service (FGIS) have any effect over the price of wheat for export. An econometric model that considered prices as a function of the implicit attributes of wheat was used. These attributes included: test weight, dockage, moisture content, percentage of foreign material, percentage of shrunken and broken kernel, and protein content. The model considered wheat demanded by millers as an intermediate good, with its final demand derived from end-consumer markets by the demand and supply for wheat derivative products. It was assumed that millers were profit maximizers under a perfect competitive scheme. Data were obtained from the FGIS during the period 1990 to 1991 (a sample of 585 wheat shipments was considered). Data included five kinds of wheat shipped to 63 different countries. Analysis to prevent multicollinearity, misspecified functional form and data irregularities were considered. It was demonstrated that the linear relationship between prices and implicit attributes was valid and there was no major misspecification problem. Results suggested that only test weight and protein content are attributes that have a significant and consistent effect over wheat prices.

In 1992, Wilson and Preszler used an input characteristic model (ICM) to analyze the impact of price, quality, and characteristic uncertainty in a selected wheat import market (the United Kingdom). An ICM was used because it accounts for the product's quality requirements, input characteristics, prices, and import market idiosyncrasy. An ICM uses regression models to estimate implicit or hedonic input characteristic values. The optimization problem was to minimize the total input cost (total ingredient cost of a straight-grade blend that used five different wheat types), subject to constraints that controlled each characteristics level. Imported wheat could be used alone or blended with other imported or domestically produced wheat. Easily measured characteristics were used as proxies for end-use performance. For example, protein quantity was a proxy for end-use performance such as farinograph absorption and loaf volume that cannot be measured directly.

Depending on the import market, Wilson and Preszler found that end-use performance variance is potentially an important source of competitive advantage. To evaluate the relationship between protein level and end-use performance a regression model was estimated for each characteristic. The dependent variables were individual wheat characteristics and the independent variable was protein content. Each characteristic expected value was derived along with the variance of the error. Conditional expected values were used for those characteristics having a significant relationship with wheat protein. They assume buyers formulate expectations about end-use performance that can be controlled through contractual specification; other characteristics have unconditional expectations. For characteristics that did not have significant relationship with wheat protein technical coefficients were unconditional expected values.

In 1989, Wilson used a hedonic price model to measure the extent of differentiation and values of quality characteristics in the international wheat market. The model considered two groups of quality variables implied in international wheat prices. The first group varied within and/or among countries. Variables included were protein, hardness and growth habit (spring or winter). Non-continuous variables were treated as binary. The second group was constant through time within a country and/or among classes. Color and grade factors such as defects, test weight, and moisture were treated as constants. Results suggested that over extended periods, there were significant implicit values for quality characteristics such as habit hardness, protein, and country of origin.

Extensions to the Literature

There is a consensus among wheat farmers that a plan to increase and assure a consistent demand for their product must be developed. Given the importance of the end-use quality characteristics on millers' purchasing decisions, the plan should begin by developing a system to capture and quantify this end-use functionality. Thus, wheat buyers would have a clearer idea of the true economic value of the wheat they have been offered and compare among selling countries.

This study follows Wilson's hedonic pricing model, however the focus of the analysis would be different. Wilson attempted to measure the implicit value of quality characteristics including country of origin as an additional characteristic. Variables such as protein, hardness, and growth habit were treated as binary. Our study uses actual values of measured characteristics, focusing on variables (or proxy variables) that would give information about end-use performance. Growth habit was not considered as a characteristic because the study would focus solely on Oklahoma hard red winter wheat.

Hedonic Price Model

According to Sirmans and Macpherson, hedonic pricing models are useful in addressing issues when valuating goods with different attributes and are the typical method to explain the value of a good by valuing the different components. The method allows the expenditure to be broken down into the values of the individual attributes. A caveat in using hedonic pricing is that results are specific and difficult to generalize. Thus, hedonic pricing models are used to better understand a particular market.

Comparing results from multiple hedonic models is complicated because each study defines and measures the variables differently, and because of different empirical specifications. Hedonic modeling uses multiple regression analysis on a pooled sample. The model assumes that consumers derive utility and valuation from various attributes of specific goods and that the value of the utility can be identified. The hedonic model takes the form: Price = f(physical characteristics, other factors). The regression estimates from the hedonic regression give the implicit prices of each variable or characteristic.

A complication in hedonic modeling is that these values are not likely to be the same for different levels of qualities. For this reason, the hedonic pricing model is often estimated in semi-log form with the natural log of price used as the dependent variable. However, Goffe states that the theory gives few indications about the functional form of the hedonic equation. The different functional forms found in the literature were: linear, log-linear, and log-log.

Wilson used a hedonic price function to measure implicit values of wheat characteristics. He stated that the logic of hedonic analysis of wheat prices is that productive inputs are demanded by processors because of particular characteristics the inputs embody. Quantity of each quality characteristic is an argument in the production function. Data was pooled across classes and countries. To account for the temporal variability in prices, International Wheat Council wheat price index (IWC) was included.

An alternative specification to capture temporal variability would be to use a time trend. All other variables were included to explain cross sectional variability. The implicit value of protein was constrained using a binary interaction term to hard wheat.

The treatment was equivalent to a linear regression where the slope of implicit value of protein with respect to non-hard wheat is assumed zero.

Separate models were estimated for two export locations in US and two international destinations. One model included the wheat price index, the variable for the time when wheat was planted, the destination country, if wheat is hard or not, and the protein level multiplied by hard, which implies that the implicit value of hardness depends on the protein level. An alternative model allowed variations among years in the implicit value of protein, allowing testing the hypothesis of temporal stability in the implicit value of protein through time. Protein was introduced as an interaction term with a binary variable for individual years and hardness. Thus the implicit value of protein was restricted to hard wheat and was allowed to vary among years. The implicit value of hardness depended on the protein level and varies by year. Data were obtained from the World Wheat Statistics. Separate models were estimated for two FOB export locations in the US, FOB Gulf and FOB Pacific, two international destinations, CIF Rotterdam and CIF Japan. Quality information was obtained from the International Wheat Council. HRW has traditionally been a common specification and trading rules establish a protein level of 11% which was used in this study. Moisture content varied across exporting countries and classes and is inversely related to the protein content. Protein was adjusted to a constant 12% moisture basis using either specified or traditional levels of moisture for each class/origin. The relative high moisture imputes a larger negative effect on its protein level, but the transformation results in more comparable measures of protein content. Separate models were estimated for each market. Prices were deflated for each individual country. Ordinary least squares (OLS) was used, and the model was tested for heteroscedacity, and autocorrelation in error terms. Results showed the implicit values of quality characteristics of interest. There is an implied additional value for spring – planted wheat relative to winter, at least at the higher protein levels, holding other factors constant. There are substantial implicit premiums for Canadian Wheat. The implicit premium for hard wheat over soft has been diminishing in recent years. Implied value of protein has been stable in some markets but has been increasing in the 80's in the Japanese market.

Model Description

Following Langyintuo et al. the present study attempts to model price as a linear summation of the implicit value of the good's attributes.

$$p_i = \sum \left(\frac{dX_{0j}}{dq_i} \right) \left(\frac{dU / dX_{0j}}{dU / dE} \right) \quad [1]$$

If assuming constant marginal implicit price the last expression can be represented by β_{ij}. Also, if one assumes that all wheat characteristics are constant, then $dU/dX_{0j} = X_{ij}$ and the marginal yield is assumed constant. So the functional form is expressed as:

$$P_i = \sum_{j=1}^{m} X_{ij} \beta_{ij} + v$$

where P_i is the price of wheat, X_{ij} is the quantity of attribute j, β_{ij} is the implicit price of attribute j, and v is the stochastic error term. The implicit values of the characteristics can be estimated and can be used to estimate the wheat price. An OLS regression would

[1] P_i is the market price, X_{0j} is the total of the mth attributes of wheat, q_i is the amount bought of wheat, i, E is the total expenditure. dX_{0j}/dq_i is the marginal yield of the jth wheat characteristic by the ith product. The marginal utilities of the jth product characteristic and of income are respectively: dU/dX_{0j} and dU/dE and is the marginal implicit price of the jth characteristic.

be performed, considering prices as implicit variables, and the marginal effect of quality attributes as explicit variables.

Data

The data were obtained from two different sources. Data about the quality attributes were from Plain Grains Incorporated (PGI). Data about the price basis were obtained from the Kansas City Board of Trade.

The model considered price basis as follows:

Price basis = f (test weight, protein content, dockage, total defects, flour yield,

rate of water absorption, peak time, stability, p/l ratio, volume, year)

where price basis represents the average annual (marketing year) basis for a given elevator. Test weight is the weight of a bushel of grain. Protein is a key parameter, related to both water absorption and gluten strength. Total defects include shrunken/ broken kernels, foreign material, insect-damaged kernels, and heat-damaged kernels; the more wheat kernels with these characteristics the less flour yields. Flour yield refers to the quantity of flour that a determined volume of wheat grains may yield. Absorption rate is the ability of the flour to absorb the amount of water required for a flour to be optimally processed into end products. Peak time indicates dough development time as measured by a farinograph. Stability time is the time the dough maintains maximum consistency and is an indicator of dough strength, also measured by a farinograph. The p/l ratio is a milling industry measure of the balance between dough strength and extensibility as measured by an alveograph. Extensibility measures the dough resistance to stretch. Volume refers to the volume of bread resulting from the wheat flour used.

Data were available for both 2004 and 2005, and year was included as a dummy variable in the regressions.

Results

Three different functional forms were estimated using SAS: linear, log-linear, and log-log models. Some parameters such as peak time, stability and p/l ratio may have some correlation. A Pearson correlation test was performed, and it showed that farinograph stability and peak are correlated (0.73). Thus, farinograph stability was included but not peak, as stability is a more commonly requested functionality parameter. Falling number data, which is commonly used as a proxy for absorption, was not available. Bread crumb acceptability and texture were not included because the data consisted of scores on a 1-10 scale that showed little variation. Finally, the variable year was omitted because it was correlated with other variables. Table 1 exhibits the results from the three models (three different functional forms) for the parameters of test weight, protein, dockage, total defects, flour yield, bake absorption, farinograph stability, alveograph p/l ratio, and bread volume. A Reset test was conducted to test for misspecification regarding functional forms. Results show that there is no evidence of misspecification with the linear and log-log models, whereas there is evidence of a misspecification with the semi-log model.

Table 1. Ordinary least squares (OLS) results for linear, semi-log, and log-log functional forms results

Variable	Linear model	Semi-log model	Log-log model
R- square	.540	.442	.415
Akaike Information Criterion (AIC)	-84.842	43.838	45.284
Volume bread	.0004 *	.003	2.497
	(2.13)	(1.86)	(1.83)
Alveograph P/L ratio	.070	.315	.282
	(1.03	(.54)	(.48)
Farinograph stability	.005	.028	.109
	(1.01)	(.62)	(.26)
Bake absorption	-.030 *	-.196	-10.209
	(-2.62)	(-2.00)	(-1.74)
Flour yield	-.002	-.0132	-1.870
	(-.28)	(-.27)	(-.51)
Total defects	-.018	-.136	-.151
	(-.79)	(-.70)	(-.49)
Dockage	-.085	-.494	-.154
	(-1.69)	(-1.15)	(-.80)
Protein AI	.028	.153	1.745
	(1.56)	(1.01)	(.89)
Test weight	.041 *	.297 *	17.786 *
	(3.48)	(2.92)	(2.71)

Values in between parenthesis indicate the t-value and values with an asterisk indicate that the parameter is statistical significant at .05% level of significance.

In the linear model, bake absorption, total defects and test weigh were statistically significant at .05% level. For the linear-log and log-log models only test weight was significant. There is evidence to conclude that the linear model will give more accurate results because the Akaike Information Criterion, ad-hoc criterion to test for the model's accuracy shows that the linear model value is better than the other functional forms.

Table 2 shows the results for the three functional forms utilizing only the independent variables that are currently measured during the transaction (i.e. can be quickly measured at the grain elevator or load-out facility).

Table 2. Ordinary least squares (OLS) results for linear, semi-log, and log-log functional forms results; considering the parameters currently measured during the transaction.

Variable	Linear model	Semi-log model	Log-log model
R- square	.244	.180	.184
Akaike Information Criterion (AIC)	-79.970	45.400	45.280
Total defects	.012 (.53)	.104 (.55)	.210 (.74)
Dockage	-.108 * (-2.10)	-.677 (-1.63)	-.295 (-1.69)
Protein AI	.010 (.72)	.060 (.56)	.606 (.47)
Test weight	.021 (1.92)	.154 (1.71)	9.411 (.1.71)

Values in between parenthesis indicate the t-value and values with an asterisk indicate that the parameter is statistical significant at .05% level of significance.

Results indicate that when considering only the parameters that are actually measured at the transaction, only dockage is significant at .05% for the linear model.

Table 3. Ordinary least squares (OLS) results for linear, semi-log, and log-log functional forms results; considering functionality parameters

Variable	Linear model	Semi-log model	Log-log model
R- square	.101	.102	.101
Akaike Information Criterion (AIC)	-72.763	50.133	50.166
Volume bread	.0003 (1.26)	.003 (1.25)	1.805 (1.20)
Alveograph P/L ratio	.040 (.57)	.225 (.41)	.151 (.29)
Farinograph stability	.0003 (.05)	-.006 (-.12)	-.129 (-.27)
Bake absorption	-.012 (-.99)	-.083 (-.92)	-4.233 (-.83)
Flour yield	-.002 (-.29)	-.010 (-.19)	-.990 (-.27)

Values in between parenthesis indicate the t-value and values with an asterisk indicate that the parameter is statistical significant at .05% level of significance.

Results indicate that when considering only the functionality parameters, none of the parameter estimates are significant at .05% for all the functional forms.

Additionally, parameters were estimated using a non-linear OLS method with a robust covariance estimator, the heteroskedasticity consistent covariance matrix estimator (HCCME). Two ways of estimating the HCCME are included[2]. Refer to Table 2. Results show that using the HCCME method e^2; the parameters bread volume, bake absorption, dockage, protein content, and test weight are significant for the variations in price basis at 0.05% of significance level. Whereas when using the HCCME method $e^2/(1-h)^2$, only test weight showed statistical significance.

Table 4. OLS – HCCME results.

Variable	HCCME= e^2	HCCME=$e^2/(1-h)^2$
R- square	.540	.540
Adj R-square	.332	.332
Volume bread	.0004 * (2.79)	.0004 (1.72)
Alveograph P/L ratio	.070 (1.02)	.070 (.67)
Farinograph stability	.005 (1.72)	.005 (1.05)
Bake absorption	-.030 * (-2.86)	-.030 (-1.82)
Flour yield	-.002 (-.42)	-.002 (-.26)
Total defects	-.018 (-.95)	-.018 (-.56)
Dockage	-.084 * (-2.12)	-.085 (-1.14)
Protein AI	.028 * (2.96)	.028 (1.76)
Test weight	.041 * (4.79)	.041 * (2.91)

[2] There are three ways to estimate the HCCME, one is including the e^2, estimates for square errors in the covariance matrix. The other way is to correct the errors with the identity matrix "h": $e^2/(1-h)^2$.

Values in between parenthesis indicate the t-value and values with an asterisk indicate that the parameter is statistical significant at .05% level of significance.

Discussion and Conclusions

The model attempted to identify those wheat attributes that have significance over prices, with an emphasis on those attributes related with end-use performance. Further treatment to the data may give better results and clarify what are the attributes that are relevant for prices.

In general, the parameters that are significant for changes in the price basis are bread loaf volume, absorption, dockage, protein content, and test weight. Results conform to previous assumptions that functionality parameters may cause price basis variations, as is the case of bread volume, bake absorption, and protein content. However, due to the nature of the analysis it is not possible to measure any premium or discount for these parameters. This study might be complemented with prices paid by wheat importers and actual milling and baking specifications as stated in trade contracts. Also, it may be helpful to obtain the information directly from the miller's purchasing managers.

For future research, efforts will be made to identify the parameters deemed most important to millers purchasing U.S. hard red winter wheat and an indication of their value. Such information will allow for direct estimation of the impacts of these parameters on the final transaction price for U.S. hard red winter wheat sourced from states such as Texas, Oklahoma, Kansas, Nebraska, and Colorado.

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