Hedonic Prices in the Malting Barley Market

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An important characteristic in the malting barley market is the multitude of quality variables which affect the value of particular samples. The purpose of this study was to estimate implicit (or hedonic) prices for selected quality factors. An econometric model was used to analyze factors affecting the variability in malting barley prices, and to estimate implicit prices for plumpness and protein. The results indicate that a change may be evolving in the price determination process for malting barley. In particular, the feed grains sector has had increasingly less effect on malting barley prices in recent years.

The major domestic use for barley has traditionally been in feed rations for livestock and poultry. However, since 1970 the proportion of barley used for malting purposes has been increasing, and in recent years nearly 50 percent of total domestic use has been for malt production. Malt is used as an input to the brewing process for the production of fermented alcoholic beverages, primarily beer. Because of the brewers' taste preferences, buyers of malting barley are very sensitive to the quality characteristics contained in different samples. Many factors affect the value of particular samples of barley in malting. Test weight, foreign material, skinned and broken kernels, soundness, and damaged kernels—all of which are part of the grade standards—influence buyers' decisions on the suitability of a malting barley sample. In addition, nongrade factors, such as protein content and plumpness, and factors inherent to each variety (e.g., color, extraction rate) affect the value of particular barley samples. In any given day, observed large price differentials may exist for relatively small variations in quality. Indeed, one of the more frustrating problems for producers, merchandisers, processors, and breeders is the large differences in malting barley prices across shipments.

The effect of quality variability on price can be analyzed using characteristic demand functions. The logic of these models is that productive inputs or consumer goods are demanded because of the characteristics they possess. The quantity of each quality characteristic (as opposed to the quantity of the input or consumer good) is an argument for the production or utility function. The theory of consumer goods characteristics demand is attributed to Lancaster. Ladd provides a thorough review of applications of both the consumer goods characteristics model and the neoclassical input characteristics model. The input characteristics approach to empirical price analysis in agriculture has been used previously by Waugh for fresh vegetables; by Johnson, as well as Menkaus and Kearl, for cattle; and by Hyslop for wheat. Ladd and Martin used it for evaluation of the grading system for corn in the United States. Ladd and Suavannunt used the approach in price analysis of consumer foods. More recent research in hedonic prices have been reported in Rosen; Carl *et al.*; Margolius and Tilley; Edmonds; and Ethridge and Davis. He-

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donic price functions are specified and estimated using standard regression procedures, and the coefficients can be used to derive estimates of marginal implicit prices for the characteristics.

The objectives of this study are to develop and estimate a hedonic price function in the malting barley market and derive estimates of the marginal implicit prices of the characteristics. The marginal implicit price of a characteristic is an economic concept similar to premiums and discounts commonly used in the grain trade and indicates the market determined value of a quality attribute. These results are useful to producers in making production and marketing decisions, to merchandisers throughout the market system, and to plant breeders making decisions on trait selection in breeding programs in which large expenditures are made.

Theoretical and Empirical Models

Malting barley is a productive input used to produce malt and eventually beer and has several characteristics. One of the important features of the market for malting barley is the heterogeneity in quality across shipments. As a result, observed prices vary across shipments in response to their characteristics. The input characteristics model views inputs as being useful because of the content of their characteristics. An input characteristic production function can be used with the neoclassical theory of the firm to derive marginal implicit prices, or imputed prices, for each of the characteristics.

Theoretical Model

Hedonic price analysis was initially presented in the literature as an empirical concept (see, for example, Griliches and Court). Lancaster developed a theoretical model of characteristics demand for consumer goods which provided a conceptual framework for previous and subsequent empirical analyses. Rosen further refined the theory of hedonic prices with particular emphasis on market equilibrium. Much of the theoretical development and applications of product characteristics demand analysis applied to agriculture for both inputs and consumer goods can be attributed to Ladd (in particular Ladd; Ladd and Martin; Ladd and Suavannunt).

The theoretical development assumes a perfectly competitive, multiproduct firm where each production function is independent of the other production functions. The production function using input characteristics is

$$q_y = f_y(q_{1y}, q_{2y}, \ldots, q_{my}) \tag{1}$$

where q_y is the quantity of output y produced, and q_{jy} is the total quantity of characteristic j ($j = 1, \ldots, m$) used in the production of y. The firms' profit function is

$$\pi = \sum_{y=1}^{Y} P_y f_y(q_{1y}, q_{2y}, \ldots, q_{my}) - \sum_{y=1}^{Y}\sum_{i=1}^{n} P_{x_i} X_{iy} \tag{2}$$

where P_y and P_{x_i} are output and input prices respectively, and X_{iy} is the quantity of input i used in the production of y. The total quantity of each characteristic, q_{jy}, is a function of both the quantity of input use, x_{iy}, and the quantity of characteristic j contained in each unit of x_{iy}. Consequently, maximization of (2) requires the function of a function rule for differentiation.[1] Maximizing (2) and solving for P_{x_i} gives

[1] In particular:

$$q_{jy} = f_j(x_{1y}, x_{2y}, \ldots, x_{iy}, x_{j1y}, x_{j2y}, \ldots, x_{jny})$$

where x_{jny} is the quantity of the characteristic j con-

$$P_{x_i} = P_y \sum_{j=1}^{m} (\partial f_y/\partial q_{jy})(\partial q_{jy}/\partial x_{iy}) \quad (3)$$

where $\partial q_{jy}/\partial x_{iy}$ is the marginal yield of characteristic j in the production of y from input i, and $P_y\ \partial f_y/\partial q_{jy}$ is the value of the marginal product of characteristic j used in the production of y. This can be interpreted as the marginal implicit price of the characteristic, or the imputed price of the j^{th} characteristic in the production of y, and is also frequently referred to as the "hedonic price."[2]

Equation (3) states Ladd's hypothesis that the observed price for each input is equal to the summation of the values of the marginal yield of the characteristic of the input in the production of the output. In other words, the purchase price of an input equals the sum of the marginal implicit prices of the characteristics possessed by the input, multiplied by the marginal yield of those characteristics. Equation (3) is sometimes called the hedonic price function and is simply a restatement of the first order condition. It indicates that the market price for inputs depends on the characteristics which they possess.

tained in each unit of x_{iy}. It follows that the production function can be restated as:

$$q_y = G_y(x_{1y}, x_{2y}, \ldots, x_{ny}, x_{j1y}, x_{j2y}, \ldots, x_{mny}).$$

Using the function of a function rule for differentiating (2), setting the results equal to zero, and solving for P_{xi} yields Equation (3).

[2] The theoretical model developed here is strictly demand oriented. In particular, Equation (3) is a model of the demand for input characteristics in production, and does not consider the supply of the input characteristics (Ladd and Martin, p. 30). The implicit assumption is that the supply of an input characteristic is perfectly inelastic with respect to its marginal implicit price in any given time period. Only recently has the goods characteristics literature discussed market equilibrium properties (Rosen and Edmunds).

Empirical Model

The hedonic price function in (3) is simplified by setting $P_y(\partial f_y/\partial q_{jy}) = B_j$. The right hand side of (3) becomes $\sum_{j=1}^{m} B_j \partial q_{jy}/\partial x_{iy}$ which is the value of the marginal yield of characteristic j from the i^{th} input. It is simplified further by assuming that B_j is constant and that $\partial q_{jy}/\partial x_{iy} = x_{jiy}$ where x_{jiy} is the quantity of characteristic j contained in each unit of x_{iy} which is assumed constant. With these assumptions, the hedonic price function can be written as

$$P_{x_i} = \sum_{j=1}^{m} B_j(x_{jiy}) \quad (4)$$

where B_j is the marginal implicit price for characteristic j.[3] This equation provides the empirical hypothesis that for each input purchased, prices can be expressed as the sum of the products of the marginal yield of the characteristic and the marginal implicit price of the characteristic. Standard regression analysis is one method to test hypotheses about the behavior of the parameters and to estimate values of the characteristics of the inputs.[4]

Prices of malting barley vary across shipments in response to protein levels and kernel plumpness and with respect to grades and varieties. Protein and plumpness are not in the grade standards but are the most important identifiable characteristics of barley for malting. A minimum level of protein is important because it acts as a source of nitrogen for yeast metabolism and growth during fermentation and

[3] The economic implications of these assumptions are that yields of the characteristics are constant, and that P_{xi} is linearly related to X_{jiy} (i.e., the marginal implicit prices are constant).

[4] An alternative methodology would be to develop a linear programming model of a process, and the shadow prices would represent the marginal implicit prices (Ladd).

provides the enzymes necessary to convert starch to fermentable sugars. Barley with a high level of protein, however, is undesirable because it produces a beer with unstable clarity. Consequently, maltsters generally try to avoid barley over 14 percent protein (Heid and Leath) and pay premiums for lower levels. Kernel plumpness affects the evenness of germination and the amount of extract that can be produced from a bushel of barley (Briggs). Since kernel plumpness is associated with a higher rate of germination, premiums are paid for high levels of plumpness.

Malting barley is usually sold by variety (i.e., variety identification is preserved) on the basis of a sample. An industry association approves varieties of barley for malting purposes, each with inherent "varietal characteristics" (e.g., color and extraction rates). The structure of the characteristics demand for barley is variety dependent because tastes and preferences of brewers (and therefore maltsters) are subjective with respect to these varietal characteristics. Each sample of barley is assigned a grade according to the Official United States Standards for Grain (United States Department of Agriculture). Grades and grade requirements differ for each barley subclass.[5] Those for six-rowed malting barley are as follows: minimum limits of test weight, suitable malting type and sound barley; and maximum limits of damaged kernels, foreign material, other grains, thin and black barley, and skinned and broken kernels. There are three grades for this subclass which depend on the values of these grade factors.

The quality attributes and grading system indicate the variables to be included in the empirical specification of hedonic price function for malting barley. Plumpness and protein are continuous variables indicating the quality attributes of a sample of malting barley; variety is introduced as a binary variable. In the first two years of the study, Beacon and Larker were the only varieties included in the sample. In 1980/81 and 1981/82 two additional varieties, Morex and Glenn, were included. Each is a six-rowed variety which is the predominate subclass sold at the Minneapolis Grain Exchange.[6] Even though each individual grade factor may influence buyers' decisions on the value of particular samples, only the assigned grade (i.e., 1, 2, or 3) is reported. Consequently, two binary variables were included in the empirical specification to account for grade. The price of feed barley was also included in the model to account for intracrop year changes in fundamentals affecting the feed grains sector which is an important potential alternative use for malting barley.

The general empirical equation was specified as:

$$P_{it} = \gamma_0 + \sum_{a=2}^{n} \gamma_a V_a + \sum_{r=2}^{3} \delta_r G_r + \beta_1 PRO_{it} + \beta_2 PLU_{it} + \theta FDBAR_t + e_{it}. \quad (5)$$

Where

P_{it} is the price of the i^{th} sample of malting barley in time t;
V_a is the intercept shifter for variety, n = 2 in 1978/79 and 1979/80 and n = 4 in 1980/81 and 1981/82;
G_r is the intercept shifter for grade;

[5] There are three classes of barley in the official standards (six-rowed barley, two-rowed barley, and barley) and subclasses within each class. There are three subclasses of the class six-rowed malting barley (six-rowed malting barley, six-rowed blue malting barley, and six-rowed barley). All of the samples analyzed in this study were in the subclass six-rowed malting barley.

[6] Two-rowed varieties are generally of lesser importance in the United States and are grown predominantly in the western states.

PRO_{it} is the percent protein in sample i in t;
PLU_{it} is the percent plumpness in sample i in t;
$FDBAR_t$ is the price of feed barley in t;
e_{it} is the error term.

Coefficients of particular importance are β_1 and β_2 which can be used to derive values of marginal implicit prices for plumpness and protein. Alternative versions of equation (5) were used to test for 1) the appropriateness of pooling, 2) homogeneity of the marginal implicit prices across the classification variables, and 3) constancy of the marginal implicit prices.

Data Sources and Estimation

The Minneapolis Grain Exchange is the only organized public market for malting barley; consequently, price discovery at this market plays an important role in establishing prices and price relationships throughout the United States and other countries. The data used in this study were for spot transactions of malting barley at this market. Malting barley is sold on the basis of samples displayed by commission firms on the floor of the Exchange. Most samples represent a railroad car located at country elevators in North Dakota, South Dakota, and Minnesota. Accompanying each sample is a "pan ticket" on which results of the official inspection and other information important to the sale are recorded. The inspection includes data on both grade (i.e., the assigned grade) and nongrade quality factors (e.g., variety, plumpness, and protein). The *Daily Market Record* quotes variety, numerical grade, percent plumpness, protein content, and price for each carlot sold on the Exchange floor. This information was collected for every Wednesday over the period 1978/79 to 1981/82 crop years. The last crop year contains only the first six months when this analysis was undertaken. There were 1,101, 1,218, 1,032, and 699 carlots used in the analysis in crop years 1978/79, 1979/80, 1980/81, and 1981/82, respectively.

Separate hedonic price functions were estimated for each of the four crop years in order to reduce the potential problems of inter-crop year variability in the marginal implicit prices. These could be attributed to changes in the supply and/or demand for the characteristics which would largely stem from the varieties produced, weather, and agronomic practices. Varieties produced and marketed were not the same throughout the time periods covered in this analysis, and each has potentially different yields of quality characteristics, as well as inherent varietal attributes. Agronomic practices (e.g., fertilization which is positively related to protein) and weather during the growing and harvest seasons affect the yield of quality characteristics and therefore supply. Consequently, estimation of one equation for all four years of data would potentially suffer from aggregation bias because of the inability to account for these unmeasurable supply side influences.[7] Estimation of separate hedonic price functions for each year allows for a different equilibrium value for the marginal implicit prices, rather than constraining them to be equal across years.

The data consisted of a cross section of observations for Wednesday of each week. However, the number of cross-sectional observations was not equal across each time period. Separate regression coefficients could have been estimated for each week, but the large number of parameter

[7] Pyler does indicate qualitatively that in the first three years of the study, the supply of the characteristics changed. However, this information was very aggregated because it was an average across samples collected from North Dakota, South Dakota, and Minnesota and was only available for crop years 1977/78 to 1980/81. Consequently, it was not possible to include these effects in the model.

TABLE 1. Tests of Hypotheses of Constancy in Implicit Prices across Varieties and Grades (F Ratio).

Classification	1978/79		1979/80		1980/81		1981/82	
	Protein	Plumpness	Protein	Plumpness	Protein	Plumpness	Protein	Plumpness
Variety	0.06	7.54*	10.44*	4.94*	2.01	10.39*	0.57	1.93
Grade	1.32	0.97	0.82	0.91	0.63	0.09	0.23	0.75

* Indicates rejection of the null hypothesis at the 5 percent level of significance.

estimates would have made presentation and interpretation of the results unnecessarily voluminous. As an alternative, the cross-section data for each Wednesday were pooled throughout the crop year, resulting in one estimated hedonic price function for each year. Analysis of covariance was used to test the appropriateness of pooling following Maddala (pp. 322–325). Hypotheses were posed that the intercept terms and slope coefficients were equal across months.[8] The hypotheses of equal intercepts across months was rejected at the 5 percent level, but that of equal slopes could not be rejected. To account for the heterogeneity in the intercept term across months, 11 monthly dummy variables were added to the empirical hedonic price function that was then estimated using the pooled data.

Standard regression procedures were used to estimate the regression coefficients. Problems associated with using pooled data are the potential for serial correlation and the heteroscedasticity in the error terms throughout the ranges of protein and plumpness. The estimated models were tested for constancy of the error terms using the Goldfeld-Quandt test which is applicable to large samples. In all cases the assumption of homoscedasticity could not be rejected. It was not possible to test for the existence of serial correlation or to use recently developed procedures for estimation with pooled data because of the unequal number of observations in each cross section.

Empirical Results and Hypothesis Testing

The empirical model is unrestricted across several parameters and provides a framework for testing hypotheses about the equality of some of the regression coefficients. In particular, the empirical equation represents a three-way fixed effects analysis of covariance (ANOVA) model with two covariates. Variety, grade, and months are the three class factors with four, three, and twelve levels, respectively. Analysis of covariance was used to test hypotheses about the equality of the slope coefficients and equality of the intercept shifters. In the first case it was hypothesized that the slope coefficients were homogeneous across varieties and grades.[9] The homogeneity test determines whether the implicit prices estimated from the regression model are statistically different across these classification variables. Hypotheses of homogeneity in implicit prices for both plumpness and protein across varieties and grades were tested for each year, and the results are presented in Table 1. These results indicate that 1) im-

[8] The alternative would have been to test for homogeneity in coefficients across weeks, but because there were unequal numbers of Wednesdays in each year, month was used as the classification variable.

[9] Hypotheses about other interactions were also posed and tested. In all cases these were insignificant and are not reported here (see Crabtree) because they were neutral with respect to the marginal implicit prices and did not affect specification of the empirical model.

TABLE 2. Tests of Significance of Classification Variables on Malting Barley Prices (F Ratio).

Classification	1978/79	1979/80	1980/81	1981/82
Month	244.98*	51.11*	33.05*	15.16*
Variety	0.19	1.78	0.90	14.38*
Grade	0.29	0.45	0.07	2.77

* Indicates rejection of the null hypothesis at the 5 percent level of significance.

plicit prices for both plumpness and protein were not significantly different across grades, 2) implicit prices for protein were not significantly different across varieties except in 1979/80, and 3) implicit prices for plumpness were significantly different across varieties except in 1981/82.

Variety, grade, and month (because of the pooling) were included as intercept shifters in the empirical model. Statistical tests were used to determine whether the effect of these classification variables on the price of malting barley were statistically significant. The null hypothesis being tested is that the estimated coefficients of the classification variables are jointly equal to zero. Rejection of the null hypothesis indicates that significant differences exist in malting barley prices which are related to that classification variable. The results of these tests are shown in Table 2. The hypothesis of equality of coefficients across months was rejected in all years, indicating that this classification variable was significant. The effect of variety was insignificant in all years except 1981/82. The hypothesis that the intercept shifters related to grade are equal, could not be rejected in any of the years. This indicates that given the covariates in the model, price differentials could not be attributed to the sample's grade.

The empirical model (equation 5) was also tested for constancy of the marginal implicit prices by including second and third order polynomials in plumpness and protein. The results yielded insignificant second and third order parameters in protein, and an insignificant third order parameter in plumpness. Estimates of the empirical model reported here incorporate the results of hypotheses posed and tested above. In particular, grade was not included as an intercept or slope shifter, and a second order parameter was included for plumpness.

In addition, restrictions were placed on values of the slope coefficients for plumpness and protein across varieties according to the results of the tests of hypotheses. These restrictions were different for each year and are as follows (β_{1a}, β_{2a}, and β_{3a} refer to the slope coefficient for protein, plumpness, and plumpness squared, respectively, where a denotes variety):

1978/79: $\beta_{11} = \beta_{12}, \beta_{21} \neq \beta_{22}, \beta_{31} \neq \beta_{32}$
1979/80: $\beta_{11} \neq \beta_{12}, \beta_{21} \neq \beta_{22}, \beta_{31} \neq \beta_{32}$
1980/81: $\beta_{11} = \beta_{12} = \beta_{13} = \beta_{14}, \beta_{21} \neq \beta_{22} \neq \beta_{23} \neq \beta_{24}, \beta_{31} \neq \beta_{32} \neq \beta_{33} \neq \beta_{34}$
1981/82: $\beta_{11} = \beta_{12} = \beta_{13} = \beta_{14}, \beta_{21} = \beta_{22} = \beta_{23} = \beta_{24}, \beta_{31} = \beta_{32} = \beta_{33} = \beta_{34}$.

The estimated coefficients for the hedonic price functions are presented in Table 3 for each crop year.[10] The binary variable for variety represents the inherent value of a variety relative to Beacon. In the first three years of the study, the statistical results indicated that this classification was insignificant. In 1981/82, however, varieties had statistically significant differences in their inherent value. The coefficients indicate that the inherent value of Morex was 12¢ per bushel greater than Beacon, but those for Larker and Glenn were not significantly different than Beacon. Prior to 1981/82 Larker was the industry standard, Glenn and Beacon were

[10] The hedonic price functions were also estimated with the above assumptions relaxed and without the inclusion of "Feed Barley." These results are very similar to those reported here (see Wilson and Crabtree, pp. 19–22).

TABLE 3. Estimated Coefficients for the Hedonic Price Equations for Malting Barley, 1978/79–1981/82 (t-Ratios in Parentheses).

Variable	1978/79	1979/80	1980/81	1981/82[a]
Month				
August	0.15	−0.07	−0.17	0.20
	(11.29)	(2.48)	(5.97)	(8.10)
September	0.14	0.28	0.18	0.18
	(9.70)	(10.12)	(6.10)	(5.57)
October	0.08	0.28	0.22	0.09
	(3.65)	(10.59)	(6.70)	(2.27)
November	0.15	0.14	0.16	0.15
	(8.42)	(4.82)	(3.70)	(4.41)
December	0.17	−0.02	0.07	0.07
	(10.83)	(0.90)	(1.90)	(2.06)
January	0.20	−0.10	0.03	
	(12.27)	(3.32)	(0.62)	
February	0.29	−0.05	0.15	
	(14.66)	(1.47)	(3.81)	
March	(0.23)	−0.14	0.16	
	(11.91)	(4.73)	(5.00)	
April	0.30	−0.04	0.28	
	(17.51)	(1.52)	(8.19)	
May	0.34	0.07	0.35	
	(17.68)	(2.24)	(10.98)	
June	0.15	0.16	0.25	
	(6.42)	(6.24)	(7.37)	
Variety				
Larker	−0.16	0.89	−1.15	−0.03
	(0.44)	(1.33)	(1.21)	(1.04)
Morex			−0.21	0.12
			(.023)	(4.71)
Glenn			0.86	0.04
			(0.38)	(1.36)
Plumpness				0.055[b]
				(4.33)
Beacon	0.04	0.06	0.10	
	(4.83)	(4.40)	(4.73)	
Larker	0.05	0.05	0.12	
	(6.61)	(4.98)	(6.53)	
Morex			0.11	
			(6.49)	
Glenn			0.07	
			(1.23)	
Plumpness Squared				−0.0003[b]
				(3.79)
Beacon	−0.0003	−0.0003	−0.0006	
	(6.04)	(4.18)	(4.59)	
Larker	−0.0003	−0.0004	−0.0007	
	(4.48)	(4.06)	(5.71)	
Morex			−0.0007	
			(6.06)	
Glenn			−0.0004	
			(1.13)	
Protein	−0.072[b]		−0.1105[b]	−0.133[b]
	(4.89)		(11.40)	(10.69)

TABLE 3. Continued.

Variable	1978/79	1979/80	1980/81	1981/82[a]
Beacon		−0.06		
		(4.90)		
Larker		−0.11		
		(11.10)		
Morex				
Glenn				
Feed Barley	1.13	0.31	0.49	0.11
	(26.18)	(7.50)	(8.41)	(1.05)
Constant	−0.44	0.50	−0.16	2.18
	(1.48)	(0.95)	(0.22)	(3.77)
R2	0.83	0.53	0.54	0.34

[a] Only the first six months of the 1981/82 crop year were included in the sample.
[b] Following the results of the hypotheses testing (see Table 1), the values of these coefficients were not significantly different across varieties and were restricted in the results here. Consequently, the estimated coefficient is listed only once but applies to each variety.

less prominent, and Morex was not grown in significant quantities. Premiums in 1981/82 for Morex represents a shift in the industry to increased utilization of Morex because of its greater extraction rate.

The estimated coefficients in Table 3 describe the pricing structure for malting barley and can be used to derive estimates of marginal implicit prices of the quality characteristics. The estimated coefficients for plumpness varied across varieties except in 1981/82. Those for protein were the same across varieties except in 1979/80. These restrictions simply indicate the homogeneity of implicit prices for the characteristics across varieties. Marginal implicit prices are defined as the partial derivative of the hedonic price equation with respect to the quality characteristic and are as follows for plumpness and protein, respectively:

$$MIP_{PL} = \beta_{2a} + 2\beta_{3a}\ PLU$$
$$MIP_{PRO} = \beta_{1a}$$

The estimated coefficients indicate that the marginal implicit price for plumpness is linear, but dependent on the level of plumpness; in other words, prices increase with increases in plumpness, but at a decreasing rate. The estimated coefficients indicate that the marginal implicit price of protein in the malting barley market is negative.

Marginal implicit prices for protein and plumpness were calculated from the estimated equations for each year and are shown in Table 4. The marginal implicit

TABLE 4. Estimated Marginal Implicit Prices for Plumpness (at the 65 Percent Level) and Protein for Crop Years 1978/79–1981/82.[a]

	Marginal Implicit Prices for Plumpness			
	1978/79	1979/80	1980/81	1981/82
	$/Bushel			
Beacon	.004	.024	.028	.019
Larker	.014	.002	.036	.019
Morex	(1)	(1)	.026	.019
Glenn	(1)	(1)	.022	.019
	Marginal Implicit Prices for Protein			
	1978/79	1979/80	1980/81	1981/82
Beacon	−.072	−.06	−.11	−.13
Larker	−.072	−.11	−.11	−.13
Morex	(1)	(1)	−.11	−.13
Glenn	(1)	(1)	−.11	−.13

[a] Not estimated.

price for plumpness was calculated at 65 percent plumpness since its value varies throughout. The marginal implicit price for plumpness increased in the first three years of the study but has since decreased. The second order coefficient for plumpness indicates that a maximum marginal implicit price for plumpness exists. Maximizing the hedonic price function with respect to plumpness indicates the quantity of plumpness which yields the greatest price. The level of plumpness which maximizes price ranged from 67 to 94 percent plump kernels. This level varies with respect to varieties and from year to year with the exception of 1981/82.

The marginal implicit price for protein was constant across varieties except in 1979/80 and has increased in each year of the study. In the first year a one unit, or 1 percent, higher protein resulted in a discount of 7.2¢ per bushel. In 1981/82 this discount increased to 13¢ per bushel. The results indicate that the market-determined value of lower protein malting barley has increased during the study period. The implication of this observation is important to plant breeders in trait selection and to producers who can affect the protein level through agronomic practices.

Throughout the time period of this study, the coefficient associated with feed barley has decreased, and in 1981/82 was not significantly different than zero. In the first three years, fundamentals in the feed grains sector, as represented by feed barley prices, had a significant effect on malting barley prices. In 1978/79 for example, there was nearly a one-to-one relationship between changes in feed barley prices and malting barley prices. Since then, this relationship has weakened, and in 1981/82 changes in feed barley prices did not have a significant impact on malting barley prices.[11]

Summary and Conclusions

A particularly important feature of the market for malting barley is the perceived randomness in prices across samples. The cross-sectional variability in malting barley prices results in uncertainty for producers, merchandisers, processors, and plant breeders. A hedonic price function was specified and estimated to derive market-determined marginal implicit prices for protein and plumpness.

Several observations were made from the estimated equations. First, the grade variables did not have a significant effect on the level of malting barley prices, given the other variables, or on the implicit prices for plumpness and protein. An important implication which may be derived from this observation is that the current grade standards may not adequately describe factors important in determining the value of malting barley samples. Second, in the first three years of the study period there was not a significant varietal premium which was not accounted for by the other characteristics. In 1981/82, however, there was a statistically significant varietal premium for Morex. Third, the feed grains sector has had increasingly less effect on malting barley prices, and in 1981/82 it was statistically insignificant.

[11] In addition, the R^2 in 1978/79 was larger than in the recent three years. Discussions with maltsters, cereal chemists, and barley buyers did not reveal any potential omitted variables; the transition in varieties from Larker to Morex and Glenn (in 1978/79, Larker accounted for 54% of the sample and declined to 13 percent in 1981/82) was accounted for by the binary variables associated with variety, and reflected differentials in color, extraction rates, etc. However there was one apparent structural difference in the crop years. The proportion of barley acres planted with malting cultivars was lowest in 1978 and has since increased (e.g., the proportion of barley acres planted to malting varieties in North Dakota increased from 83 percent to 93 percent between 1978 and 1981, see Wilson, pp. 5–6). The effect of this may have been to make the pricing structure fundamentally more determinate in years with reduced supplies of malting barley.

Marginal implicit prices for the quality characteristics were derived from the estimated coefficients. The marginal implicit price for protein was negative (implying a discount) as expected, constant across the range of protein, and constant across varieties in each year except 1979/80. The marginal implicit price for plumpness depended on the level of plumpness and varied across varieties except in 1981/82. An important observation on the behavior of these marginal implicit prices is that the premium for plumpness increased during the first three years of the study and the discounts for protein have increased every year from 7.2¢ per bushel to 13¢ per bushel for a 1 percent change in protein. These results have important implications for plant breeders and for participants throughout the production/marketing system for malting barley. Large expenditures are made in plant breeding to improve the quality of malting barley through improved varieties. The results of this study provide a measure of the economic value of plumpness and protein and could be incorporated into plant breeding programs. These results could also be useful to producers in variety selection and production decisions to the extent that protein and plumpness levels can be influenced by soil selection and nitrogen use. Country elevators, merchandisers, maltsters, and, to a certain extent, brewers have long been aware of the uncertainty associated with marketing malting barley and of the implicit discounts for protein and premiums for plumpness. This study provides empirical results of the value of the inherent varietal premiums, implicit discounts for protein, and premiums for plumpness.

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