Differentiation and Implicit Prices in Export Wheat Markets

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This paper describes the extent and characteristics of differentiation in the international wheat market. Results indicate that the degree of differentiation has increased in the last 15 years. A hedonic price function is specified and estimated to examine implicit prices for characteristics and their changes through time.

Key words: hedonics, international, quality, wheat.

There are many different classes of wheat produced and traded in the world market. Differences among classes are due to either indigenous or extraneous characteristics. Color, protein level and quality, strength, and hardness are all indigenous characteristics. Extraneous characteristics include grade factors and nonmillable material or impurities. The quality of wheat produced and exported has the potential to be an important competitive factor in international trade. As the intensity of competition in wheat trade has increased, so has the importance of differentiation of important quality characteristics. One way to measure the extent and characteristics of differentiation is to examine prices of wheats with different characteristics.

The purpose of this paper is to measure the extent of differentiation and values of quality characteristics in the international wheat market. One empirical statistic simply measures the degree of differentiation in international wheat markets. A hedonic price function is specified and estimated using pooled data to test hypotheses about the implied values for particular characteristics. In the first section, background information is presented. Important differences exist in the quality of wheat exported. These result from the cumulative effects of agronomic practices, climate, breeding, variety release programs, and trading practices.

Results indicate that the degree of differentiation has increased substantially in the last 15 years. There are a number of other interesting results. For example, in one market implicit prices have been unstable, and in another market they have increased through time. In addition, there are substantial implicit premiums associated with country of origin. Both of these results have important implications for the competitive position of the United States.

Background

An important feature of the wheat market is that of quality-related price differentials. The purpose of this section is to describe the differences in wheat produced and exported by the major exporters. There are important differences in prices of different qualities of wheat within the United States as well as among countries. There are a number of reasons for these differences some of which can be identified using the hedonic model. Other factors, however, are country specific and have to be attributed to the cumulative effects of a country's entire production/marketing system.[1]

There are two reasons to distinguish among wheats of the same type grown in different countries or areas of the same country. One is that wheats of similar type do not possess iden-

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[1] The discussion is not comprehensive but provides an overview of the issues. Greater detail is provided in U.S. Congress Office of Technology Assessment; Hill, Zortman, and Weidner; Wilson and Hill; and Wilson and Orr.

tical characteristics. Classification by type may be too general to account for differences in demands for imported wheats. The second reason is that country of origin is thought to be one basis of differentiation in demand for wheats (Grennes, Johnson, and Thursby). Numerous classes of wheat are available from the major wheat exporting countries of Argentina, Australia, Canada, France, and the United States. Although each country exports more than one wheat class, only the United States exports multiple classes in significant amounts. Hard Red Winter (HRW) has always been the dominant class of U.S. wheat exports followed by Hard Red Spring (HRS), White (WHI), and Soft Red Winter (SRW). The remaining exporting countries are each known for one dominant class, or in the case of France, type. Argentina predominately exports Trigo Pan (TP), while Canada has established a reputation with high breadmaking quality Canadian Western Red Spring (CWRS). France exports soft wheats (EC). Australian Standard White (ASW) is the dominant class in Australian wheat exports.[2]

Color, protein level and quality, strength, and hardness are all indigenous characteristics of wheat. Some of these may be unique to each country, and most are a product of environmental conditions and breeding programs. Plant breeding programs differ greatly across producing regions and result in wide variations in inherited attributes. Differences in environment and genetics among wheat-producing areas of the world or within a country result in wide variations in the characteristics of wheats produced even among those of the same general type. The control over variety development and release varies across exporters. On the one extreme is Canada which is highly rigid, requiring visual distinguishability by variety (Carter et al.; Canada Grains Council). Other countries exert varying degrees of regulation over variety development and release and over mechanisms for declaring variety at the point of first sale (i.e., Australia and France).[3] In the United States there is little control over the release, production, and marketing of varieties. A variety's success is highly dependent on market pressures and incentives and on varying degrees of institutional evaluation.

There are several important impacts of these differing policies. One is productivity growth. The other, and of particular importance in this analysis, is uniformity. In this context, uniformity refers to end-use performance (e.g., loaf-volume). Wheat exported from the United States has been criticized by importers because it is not uniform in end-use performance.[4] In the U.S. marketing system, as an example, export shipments are comprised of many different varieties, likely from several production regions, as well as across several crop years. Even though the latter two reasons are due to the U.S. logistical system and farm policies, importers are critical of the lack of uniformity.[5]

An important indigenous characteristic affecting the value of wheat across sources and through time is the quality and quantity of protein content. Protein quality affects the gluten strength of dough; consequently, wheats high in protein are desirable for bread making. However, products typically produced with soft wheat (e.g., cakes, crackers) are chemically leavened and require low protein (Pomeranz, pp. 586–87). The quality of protein is not easily measured, and therefore the quantity of protein is used as a proxy for trading. Protein content is functionally related to genetics and environmental conditions. Consequently, the protein content of wheat varies across locations, within and among countries, as well as through time. Premiums for protein are implicitly reflected in export prices depending upon protein level. However, these are not readily observable because most reported export prices are for a particular protein level which varies only across countries. Explicit premiums for protein, however, can be identified at selected U.S. grain exchanges. This data suggests that explicit protein premiums in U.S. cash prices are unstable through time;

[2] The acronyms in parentheses are used throughout the text.

[3] See Wilson and Hill; Wilson and Orr; Hill, Zortman, and Weidner; and U.S. Congress Office of Technology Assessment for complete descriptions of these variety development and release programs.

[4] A Japanese importer, for example, cited that "the low reliability of U.S. hard red spring wheat is caused by the wide fluctuation both in milling and in baking performance, and it seems to me that the quality fluctuation among cargos is getting larger and more serious" (Nagao). This should not be taken too lightly; others have argued "in commerce, uniformity in wheat and flour quality on a continuing basis is perhaps equal in importance to the actual quality level" (Patterson and Allen, p. 47).

[5] A shipment may be uniform according to U.S. grain standards, but due to the fact that the standards do not measure end-use performance (they generally only measure physical characteristics), lack of uniformity may still exist in end-use performance. Further, the CUSIM and PUIP shiploading plans allow for specified levels of variability in physical criteria.

thus, the implicit protein premiums in export prices for hard wheats are potentially unstable as well.

There are also important extraneous differences among wheats across exporters. Important differences include grading systems, regulations over ship loading, and cleaning. Again, each of these varies across exporters. The grading systems generally use the least factor approach (i.e., the numerical grade is determined by the lowest quality of any factor), but those factors included and their limits vary.[6] A very important difference does exist and is notable in comparing the United States and Canada. Both these countries are important producers of spring-planted wheat in which the incidence of nonmillable materials exceeds that of other countries and regions. In the United States this is treated as "dockage," is not a component factor in the grading system, and is normally a deductible in transactions. Thus, removal of nonmillable material is dependent on the incentives in the market. The incidence of dockage in Canada is similar at the farm level to that in the northern United States. However, due to regulations in the marketing system, all wheat is cleaned at the point of export. The effects of these differences are illustrated in table 1, which shows the average level of nonmillable material received in wheat shipments in Japan from each source over the crop years 1983/84–1986/87. During that period, the levels of nonmillable material were constant from each source, but there was substantially more nonmillable material in shipments from the United States.

Table 1. Components of Nonmillable Material in Wheat Shipments to Japan, 1983/84–1986/87

	Dockage	Foreign Material	Total Nonmillable Material
		%	
U.S. HRS	.86	.38	1.20
U.S. HRW	.64	.40	1.04
Canadian CWRS	.14	.19	.33
Australian	.38	.10	.48

Source: Wheat Cargo Quality Analysis, U.S. Wheat Associates.

Empirical Model and Data Sources

Imbedded in the price of wheat in international markets are implicit values of particular quality characteristics. Differences in prices may be attributable to protein level, spring versus winter, and color. In addition, prices may vary due to country of origin, reflecting the cumulative effects of a country's entire production/marketing system including the grading system, breeding programs, and cargo consistency, etc.[7] Since the forces that influence these differences are institutionally entrenched, changes in indigenous or extraneous characteristics of wheat quality are very slow to evolve. The concept of differentiation is discussed in this section followed by specification of empirical measures of the extent of differentiation and values of quality characteristics.

Price variation across different goods is an indication that differentiation exists. There are two principal forms of differentiation (Greenway). Horizontal differentiation generally coincides with Hotellings' locational differentiation. In this case goods within a "group" have the same characteristics, and the manner in which these are combined determines the product specification. The existence of differentiation can be identified by the presence of a variety of specifications within a particular group. The existence of this form of differentiation depends on a diversity of preferences (e.g., color of a car). In this form prices may be equal across goods within a group, and consumption (trade) is determined by the diversity of preferences. Vertical differentiation refers to a difference in a characteristic in such a way that more is always better (e.g., a faster computer).[8] In practice it may be difficult to discretely separate horizontal and vertical differentiation. Differentiation exists because multiple specifications within a group are supplied, each with different characteristics. The extent that these different characteristics have value (i.e., from a consumer perspective) is an empirical question.

Both the Hufbauer index and the hedonic price function are measures of differentiation, in particular, vertical differentiation (Green-

[6] The exception to this is the European Community which does not have an official grading system. Privately negotiated contracts prevail with the exception of minimum quality requirements for the intervention mechanism (Wilson and Hill).

[7] Other reasons why empirical papers often violate the law of one price are discussed in Goodwin and in Officer.

[8] In addition to horizontal and vertical differentiation, a third form is technical differentiation but is not relevant here.

way). The Hufbauer index is defined as: $H = \sigma_i/\mu_i$ where σ_i is the standard deviation across goods, and μ_i is the mean. If all prices were the same, H would be zero as in pure horizontal differentiation.

The hedonic price function has the advantage because implicit values of characteristics can be estimated; consequently, it has been used widely in industry studies. The general theory of hedonic analysis of prices stems from the original theoretical work of Lancaster and of Rosen. Empirical analysis, especially in the case of agricultural products, follows the work of Ladd and Martin and of Ladd and Suvannunt. The logic of hedonic analysis of wheat prices is that productive inputs, such as different classes and origins of wheat, are demanded by processors because of the particular characteristics they embody.[9] The quantity of each quality characteristic is an argument in the production function. The first-order condition of a firm maximizing a profit function subject to an input characteristics-production function results in what is referred to as a hedonic price function. This simply indicates that the market price for an input depends on its characteristics. In general, the hedonic price function can be stated as:

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

where P_{x_i} is the price of input x, $\partial q_{jy}/\partial x_{iy}$ 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 production of y. This function can be simplified by assuming that P_y $(\partial f_y/\partial q_{jy})$ is B_j and $\partial q_{jy}/\partial x_{iy}$ is x_{jiy}, and both are constant.[10] The hedonic price function can then be restated as:

$$(2) \qquad P_{x_i} = \sum_{j=1}^{m} B_j(x_{jiy}),$$

where x_{jiy} is the quantity of characteristic j contained in each unit of X_{iy}. B_j is the marginal implicit value of characteristic j. In Rosen's terms hedonic prices are "implicit prices of attributes . . . revealed to economic agents from observed prices of differentiated products" (p. 34).

The general empirical specification is a functional relationship between prices and quality characteristics. In this study, pooled time-series and cross-sectional data are used. The general specification is:

$$(3) \qquad P_{it} = P_t(X_{it}, U_{it}) \qquad i = 1, 2, \ldots, N,$$

where P_{it} is the price of wheat type i in time t; X_{it} is a vector of quality characteristics in a unit of the i^{th} wheat in time t; and U_{it} is a random disturbance term. The implicit price of each characteristic is $\partial P/\partial X$ and is interpreted as the value implied in the price of a unit increase in that characteristic.

There are two groups of quality variables that are implied in international wheat prices. The first group varies within and/or among countries. Variables included are protein, which is a continuous variable, and hardness and growth habit (spring/winter), which are noncontinuous and treated as binary variables. Those in the second group are constant through time within a country and/or among classes. These include color and grade factors such as impurities, test weight, and moisture, all of which are constant. This second group of variables, due to their constancy, can be measured by binary variables for a particular country.

The specific model presented here incorporates several features to accommodate the data. First, the data were pooled across classes and countries. To account for the temporal variability in prices, the International Wheat Council wheat price index (IWC) was included in the model.[11] An alternative specification to capture temporal variability would be to use a time trend such as in O'Connell, but this implicitly constrains trend variables to be trending in one direction for the entire time series. Use of the IWC index is a better approximation of the temporal variability in wheat prices reflecting the general escalation during the 1970s and contraction in recent years. All other variables were included to explain cross-sectional variability. Second, from a demand perspective protein generally only has implicit value for hard wheats. Since nonhard wheats are normally not purchased for protein,[12] the implicit value of protein was constrained (using a binary interaction term) to hard wheats. This treatment is equivalent to piecewise linear regression where the slope

[9] The theory is treated here briefly. Extensive development is contained in the citations and in particular Wilson.

[10] The implications of these simplifying assumptions are that the yields of the characteristics are constant and that prices are linearly related to the quantity of the characteristic (Ladd and Martin).

[11] Since this variable only has been calculated since 1972, the model was estimated for the post-1971 period only.

[12] In fact, in some cases lower protein is desirable.

of the implicit value of protein with respect to nonhard wheats is assumed zero.

Separate models were estimated for two export locations in the United States and two international destinations. Estimation of a separate model for each specific location precludes implicit price differences associated with location. The general model is:

(4)
$$P_{it} = \gamma_0 + \gamma_1 IWC_t + \delta_1 Spring_{it} + \delta_2 Country_{it} + \delta_3 Hard_{it} + \bar{\beta} (PRO_{it} \cdot Hard_{it}) + U_{it},$$

where P_{it} is the price of wheat from origin/class i in time t; IWC_t is the International Wheat Price Index; $Spring_{it}$ is zero if a spring-planted wheat and one otherwise; and $Country_{it}$ (used only in models with international destinations) in the case of Rotterdam is zero if U.S. origin, one if Canada origin. Two country variables were included in the case of Japan with the default value being Australia; $Hard_{it}$ is one if the wheat is hard, zero if nonhard (i.e., med-hard, soft).[13] PRO_{it} is the protein level of the i^{th} wheat; and U_{it} is a random error term.

The estimated parameters δ_1 and δ_2 represent the marginal implicit value (or implied premiums or discounts) associated with *Spring* and *Country*, respectively. The implicit value of protein level is $\bar{\beta}$ and applies only to hard wheats. Similarly, the implicit value of hardness depends on the protein level. Formally, the implicit value of hardness is $\partial P/\partial Hard = \delta_3 + \bar{\beta}\, PRO_{it}$.

An alternative model was specified and estimated in which the implicit value of protein was allowed to vary among years. This allows for a test of 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 but was allowed to vary among years as represented by β_{YR} (YR = 73, 74, . . . , 86):

$$(5) \qquad P_{it} = \gamma_0 + \gamma_1 IWC_t + \delta_1 Spring_{it} + \delta_2 Country_{it} + \delta_3 Hard_{it} + \sum_{YR=73}^{86} \beta_{YR}(PRO_{it} \cdot Hard_{it}) + U_{it}.$$

The implicit value of hardness depends on the protein level and varies by year, $\partial P/\partial Hard = \delta_3 + \beta_{YR} PRO_{it}$, where β_{YR} varies through time. Equation 5 can be interpreted as an unrestricted model, compared to equation 4, which is restricted in the sense that $\bar{\beta}$ is constrained to be constant across the years. Tests were conducted regarding the stability of β_{YR} using conventional techniques by comparing the residual sum of squared errors from the restricted versus the unrestricted model. Formally, the null hypothesis is that $\beta_{73} = \beta_{74} = \ldots = \beta_{86}$ which if accepted means that the restricted model with $\bar{\beta}$ is appropriate.

In temporal hedonic price analysis it is important to use price data from one consistent source to preclude introduction of differences due to measurement. It is also necessary to use price data for specific locations to eliminate differences which stem from relative transport cost when using different locations. For these reasons the price data used in this study were taken from various issues of *World Wheat Statistics* (International Wheat Council). Separate models were estimated for two FOB export locations in the U.S., FOB Gulf and FOB Pacific, and two international destinations, CIF Rotterdam and CIF Japan. The wheat prices used in the hedonic price analysis are shown in table 2. Information on quality was taken from unpublished data from the International Wheat Council (1987). HRW Ord. has traditionally been a common specification, and trading rules establish a protein level of 11% which is used in this study. Moisture content varies across exporting countries and classes and is inversely related to the protein content. Thus, 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 of CWRS 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 from 1972/73 to 1986/87 market years (beginning July of each year). All prices and IWC were deflated with 1985 = 100 using the Producer Price Index (PPI) for each individual country (i.e., the PPI for the U.S. was the deflator for the two U.S. markets, and those for the Netherlands and Japan were used for CIF Rotterdam and CIF Japan respectively).[14] For

[13] There was only one nonhard wheat traded at each market. Thus, inclusion of the variable "hard" with a value of one means the base model is for nonhard wheats, either medium-hard or soft, depending on the market.

[14] The models for the two U.S. markets also were estimated using broader world-wide deflators, and the results were very similar to those presented here.

Table 2. Wheat Price Used in the Hedonic Price Analysis

	Country Origin	Class/Subclass	Grade	Descriptor Abbreviation
FOB Gulf	U.S.	Dark Northern Spring	No. 2	DNS
	U.S.	Hard Red Winter	No. 2	HRW 13
	U.S.	Hard Red Winter	No. 2	HRW Ord.
	U.S.	Soft Red Winter	No. 2	SRW
FOB Pacific	U.S.	Dark Northern Spring	No. 2	DNS
	U.S.	Western White	No. 2	White
	U.S.	Hard Red Winter	No. 2	HRW Ord.
CIF Rotterdam	Canada	Canadian Western Red Spring	No. 1	CWRS
	U.S.	Dark Northern Spring	No. 2	DNS
	U.S.	Hard Red Winter	No. 2	HRW 13.5
	U.S.	Hard Red Winter	No. 2	HRW Ord.
	U.S.	Soft Red Winter	No. 2	SRW
CIF Japan	Australia	Prime Hard	—	APH
	Australia	Standard White	—	ASW
	Canada	Canadian Western Red Spring	No. 1	CWRS
	U.S.	Dark Northern Spring	No. 2	DNS
	U.S.	Hard Red Winter	No. 2	HRW 13
	U.S.	Hard Red Winter	No. 2	HRW Ord.
	U.S.	Western White	No. 2	White

each of the markets, the data were pooled across types of wheat and through time. Thus, the resulting model for estimation is a covariance model with binary variables included to account for cross-sectional discrete effects.

Each model was estimated using ordinary least squares (OLS). In addition, selected models were estimated using Parks' method which corrects for both heteroskedasticity and autocorrelated error terms, common problems with pooled data. This method assumes first-order autocorrelation with contemporaneous correlation (i.e., correlation between different disturbances at a given point in time) between cross sections. In Parks' method, OLS is first used to estimate the first-order autocorrelation parameter (ρ). Estimates of (ρ) are used to remove the autoregressive characteristic of the data. The resulting transformed model is then estimated using generalized least squares. The estimation technique requires no missing values. Thus, the Parks' method could be used only for selected markets.

Empirical Results

The hedonic model developed above is used to measure the values of quality characteristics in the international wheat market and to assess implicit values associated with certain quality characteristics. Simple comparisons are made first of the behavior of relative wheat prices.

In each market the absolute level of world prices has been increasing since the 1960s. Price levels reached a peak in 1973/74 and again in 1980/81 and have since declined. Of particular interest is the behavior of relative prices. For comparison purposes, figure 1 shows the behavior of international wheat prices at CIF Japan and deflated by HRW Ord. (i.e., the ratio of a specific wheat price to that of HRW Ord.). In the years 1973/74 and preceding, the price differentials among wheat classes and origins were very small, with ratios of relative prices being very close to one. This behavior likely reflected the global food shortage situation and resultant lack of differentiation among qualities of wheats. Since 1973/74, there have been several distinct trends resulting in overall increases in the price differentials among wheats of different classes and origins. Of particular interest are the general increases in the prices of the stronger high protein wheats, i.e., DNS 14% and CWRS 13%, relative to HRW Ord. The price ratio for CWRS increased to 116% and 121%, respectively, in 1974/75 and 1975/76 and since has increased to 125%. A similar pattern occurred with DNS. However, the appreciation of DNS relative to HRW Ord. was much less than that of CWRS. Australian Prime Hard (13%) did not appreciate in relative terms compared to either CWRS or DNS.[15]

[15] Similar relative price behavior occurred at the other markets. In Rotterdam, however, CWRS increased to 130% of HRW Ord. in 1974/75 and 1975/76 and then decreased. The decrease, however, was much greater for DNS than for CWRS.

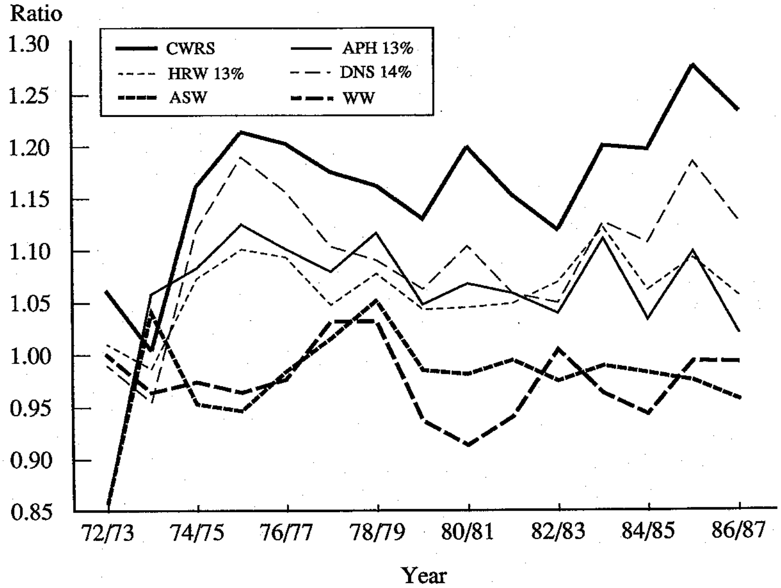

Figure 1. Import prices relative to HRW Ordinary, CIF Japan, 1972/73-1986/87

The Hufbauer index was calculated for each year at FOB Gulf, CIF Rotterdam, and CIF Japan.[16] Values for the first year of each decade as well as the most recent period are shown in table 3. The extent of differentiation is similar at each of the markets. Also, the degree of differentiation has increased substantially between the early 1970s and 1980s.

The hedonic models were first estimated in both the restricted and unrestricted specification using OLS to test the null hypothesis that the implicit value for protein, β_{YR}, was stable through time. Calculated F values were 1.99, 1.10, .46, and 5.79 for FOB U.S. Gulf, FOB Pacific, CIF Rotterdam, and CIF Japan, respectively. Those for FOB Gulf and CIF Japan were greater than their theoretical values at the 5% level resulting in a rejection of the null hypothesis. For the other two markets, the null hypothesis could not be rejected. Thus, these results indicate that the implicit values of protein at the FOB Pacific and CIF Rotterdam markets have been stable through time, whereas those of FOB U.S. Gulf and CIF Japan have been unstable.

The results are presented in tables 4–7 using several specifications. The Parks' method could not be used in a number of cases due to missing data. Results are presented including Spring and Hard first as separate variables and then combined where appropriate[17] to evaluate the sensitivity of alternative specifications. The model specifications used dummy variables as proxies for qualitative differences. In general, nonhard (medium-hard and soft) wheats were treated as default, and the implied values for hard were reflected in the nonintercept parameters. Depending on the number of types of characteristics of wheat sold in each market, the dummy variables were not capable of identifying the influences of a number of qualitative factors. For example, in the FOB Pacific market three wheats were included in the sample. White wheat was the only nonred wheat, but it was also the only nonhard wheat. The case of the CIF Japan market for U.S. wheats was similar. Also, in the CIF Japan market the Australian wheats were exclusively white, and this effect was reflected in the country variables. Thus, the models had to be specified selectively as well as interpreted appropriately to account for these identification problems.

The coefficient for spring varied across markets and was significant in each with the exception of the CIF Rotterdam market. The value of the coefficient indicates the value of spring

[16] H could not be calculated for FOB Pacific because there are too few wheat types traded at that market.

[17] In the case of the FOB Pacific market, Hard and Spring could not be combined due to the fact there was only one HRW wheat with one protein level. Thus, due to the interaction term with protein, inclusion of both Hard and Spring would result in the same variables being linear combinations of other variables. Parameter estimates would not be unique and, therefore, would be misleading.

Table 3. Hufbauer Indexes in the International Wheat Market

	1960/61	1970/71	1980/81	1986/87
FOB Gulf	.035	.047	.057	.067
CIF Rotterdam	.054	.059	.087	.091
CIF Japan	.042	.046	.089	.090

relative to winter wheat. For example, at Japan the implicit value for spring wheat, holding all other characteristics constant, was $4.96 per metric ton (MT). From a demand perspective there are important differences, reflected in the implicit values, among wheats with different growing habits. This may reflect the allegation by some cereal chemists that the quality of protein in higher protein spring wheats exceeds that of like protein winter wheats. Conclusions from the FOB Pacific market should be tentative due to the fact that there were only two hard wheats included in the sample, each with a different protein level. In each of the other markets, there were multiple hard wheats with more than one protein level.

The country of origin variables in the CIF markets are generally significant, suggesting that important differences in value are perceived across importers. Of particular interest is the substantial premium for Canadian origin wheats relative to the U.S. origin wheats in the Rotterdam market and relative to Australian wheat in the Japanese market. The implicit premiums of Canadian wheat in Rotterdam are about $20/MT and about $11/MT over Australian wheat in the Japanese market. Factors which may contribute to the differences in implicit values include the various national peculiarities in production/marketing systems. The implicit value of U.S. wheat at Rotterdam is negative compared to Canada. In the CIF Japan market, all signs for U.S. origin are negative (relative to Australian wheats). These results confirm that U.S. wheat sells at a discount to competitor wheats at important import markets. In fact, holding some measurable quality characteristics (e.g., protein) constant, U.S. wheat still takes a discount to that from other countries. In addition, an estimate is provided as to the extent of that discount.[18]

The implicit value of hard versus nonhard wheat is difficult to interpret, because it varies by protein level and by year in the FOB U.S. Gulf and CIF Japan markets but is stable in the other two markets. In the CIF Rotterdam market, for example, the implicit value of hard was $23/MT and $2/MT at the 13% and 10% protein level respectively.[19] At U.S. Gulf, the

Table 4. Hedonic Models of U.S. FOB Gulf Export Prices

	Model[a]		
Variable	1	2	3
Intercept	−6.00	−5.19	−3.64
	(10.70)	(11.64)	(8.10)
IWC	0.94*	0.92*	0.92*
	(0.04)	(0.05)	(0.04)
Spring	17.58*	—	17.90*
	(2.85)	—	(2.68)
Hard	—	10.83	12.70*
	—	(7.27)	(5.07)
Protein 73	0.16	0.28	−0.26
	(0.81)	(1.11)	(0.78)
74	1.30*	1.31	0.72
	(0.59)	(0.85)	(0.60)
75	1.68*	1.62*	0.99*
	(0.49)	(0.75)	(0.53)
76	1.05*	0.89	0.22
	(0.43)	(0.74)	(0.52)
77	0.82*	0.65	−0.03
	(0.44)	(0.75)	(0.53)
78	0.71*	0.57	−0.09
	(0.43)	(0.73)	(0.52)
79	1.06*	0.94	0.29
	(0.44)	(0.73)	(0.51)
80	0.79*	0.65	−0.01
	(0.44)	(0.73)	(0.51)
81	1.15*	0.96	0.28
	(0.44)	(0.77)	(0.54)
82	0.95*	0.75	0.06
	(0.45)	(0.78)	(0.55)
83	0.90*	0.69	0.001
	(0.45)	(0.79)	(0.56)
84	0.68	0.46	−0.23
	(0.47)	(0.81)	(0.57)
85	0.23	0.01	−0.70
	(0.47)	(0.81)	(0.58)
86	−0.15	−0.19	−1.06*
	(0.55)	(0.89)	(0.63)
Adj. R^2	.98	.99	.99

Note: Standard errors in parentheses. Asterisk indicates significant at the .10 level.
[a] All models estimated using OLS due to missing values for selected prices during some years.

[18] However, it would be beyond the capabilities of this paper, and for that matter currently available information, to make any conclusions about the costs of changing the system in the U.S.

[19] Derived using the results of Model 3: $\frac{\partial P}{\partial Hard} = -69.40 + 7.14$ $(PROT)$.

Table 5. Hedonic Models of FOB Pacific Export Prices

Variable	Model[a] 1	2	3
Intercept	−10.90*	−10.90*	−6.98*
	(4.90)	(4.92)	(3.53)
IWC	0.98*	0.98*	0.97*
	(0.03)	(0.02)	(0.008)
Spring	23.97*	—	24.91*
	(4.29)	—	(6.17)
Hard[b]	—	−85.65*	—
	—	(15.35)	—
Protein	0.35	8.18*	0.31
	(0.33)	(1.20)	(0.218)

Note: Standard errors in parentheses. Asterisk indicates significant at the .10 level.
[a] All models estimated using Parks' method where values of Rho are: Rho = .41, .22, .31 for i = 1, 2, and 3, respectively.
[b] The coefficient for Hard also reflects that of color (i.e., red versus white which is imbedded in base case).

implied premium for hard over nonhard at the 13% level was $9.32/MT, $16.34/MT, and $−1.08/MT in 1973/74, 1981/82, and 1986/87 respectively (Model 3).

The implicit value of protein was significant in each market; however, interpretation varies. The implied value of protein did not vary significantly throughout the period for the FOB Pacific and CIF Rotterdam markets. The value of the coefficient can be used to derive implicit

Table 6. Hedonic Models of CIF Rotterdam Import Prices

Variable	Model[a] 1	2	3
Intercept	−15.45*	−15.22*	−15.22*
	(7.67)	(7.38)	(7.46)
IWC	1.04*	1.04*	−1.05*
	(0.03)	(0.03)	(0.03)
Spring	8.94	—	0.05
	(5.71)	—	(6.98)
Hard	—	−69.55*	−69.40*
	—	(26.10)	(33.16)
Canada	18.93*	20.41*	20.39*
	(5.69)	(4.86)	(5.58)
Protein	1.64*	7.16*	7.14*
	(3.57)	(1.96)	(2.67)
Adj. R^2	.95	.95	.95

Note: Standard errors in parentheses. Asterisk indicates significant at the .10 level.
[a] All models estimated using OLS due to missing values for selected prices in middle of time series.

Table 7. Hedonic Models of CIF Japan Import Prices

Variable	Model[a] 1	2	3
Intercept	−9.85	−7.21	−5.38
	(6.99)	(6.05)	(6.16)
IWC	1.14*	1.14*	1.13*
	(0.03)	(0.28)	(0.03)
Spring	6.42*	—	4.96*
	(1.91)	—	(1.85)
Hard[b]	—	−11.27*	−7.25*
	—	(3.78)	(4.15)
Canada	9.67*	16.31*	11.14*
	(2.02)	(1.99)	(2.55)
U.S.	−6.33*	−1.93	−4.88*
	(2.54)	(1.96)	(2.26)
Protein 73	1.81*	2.26*	2.09*
	(0.51)	(0.47)	(0.49)
74	1.86*	2.15*	1.96*
	(0.33)	(0.32)	(0.36)
75	1.61*	2.38*	2.04*
	(0.26)	(0.25)	(0.30)
76	1.48*	2.05*	1.68*
	(0.27)	(0.36)	(0.33)
77	0.64*	1.24*	0.91*
	(0.27)	(0.29)	(0.33)
78	0.94*	1.55*	1.24*
	(0.24)	(0.20)	(0.26)
79	2.42*	3.12*	2.89*
	(0.23)	(0.26)	(0.30)
80	2.44*	3.04*	2.76*
	(0.23)	(0.25)	(0.29)
81	2.32*	3.14*	2.75*
	(0.21)	(0.30)	(0.33)
82	2.71*	3.56*	3.10*
	(0.23)	(0.30)	(0.33)
83	2.77*	3.56*	3.13*
	(0.23)	(0.29)	(0.32)
84	1.83*	2.63*	2.18*
	(0.24)	(0.32)	(0.35)
85	1.80*	2.61*	2.20*
	(0.25)	(0.32)	(0.35)
86	1.91*	2.69*	2.27*
	(0.28)	(0.35)	(0.37)

Note: Standard errors in parentheses. Asterisk indicates significant at the .10 level.
[a] All models estimated using Parks' method where values for Rho are: Model 1 −.33, −.22, .23, .46, .39, .72, and .44 for i = 1, 2, . . . , 7, respectively. Model 2 −.34, −.33, .44, .53, .42, .73, and .44 for i = 1, 2, . . . , 7, respectively. Model 3 −.41, −.17, −.22, −.04, .33, .44, and .42 for i = 1, 2, . . . , 7, respectively.
[b] The coefficient for hard also reflects that of color (i.e., red versus white which is imbedded in the base case).

values for wheats of a particular protein level. At the FOB Pacific market, for example, the implied value is $8.18/MT per 1% of protein. Thus, the values of 11% and 14% protein are

$90/MT and $115/MT, respectively, implying a $25/MT premium for the latter protein level (Model 2). Similar calculations at Rotterdam result in a $21/MT premium for the higher (14%) protein value (Model 2). The implicit value of protein varied throughout the period in the case of the FOB U.S. Gulf and CIF Japan markets. At the U.S. Gulf, the implicit value of protein was unstable, but there was not a noticeable trend. In Japan, the implicit value of a 1% unit of protein increased from $1.96/MT in 1974/75 to $3.13/MT in 1983/84. Potential reasons for the apparent increasing value of protein in the Japanese market are processing technology and the types of products produced. As an example, the processing technology used in Japan differs from that of Europe—the latter being more capable of substituting gluten for higher protein wheat imports. This is due to the types of products and the high degree of automation in Japan, which requires stronger wheats.

Summary

There are important indigenous and extraneous differences in wheat quality, both within and among exporting countries. These differences are due to the cumulative effects of tradition and agronomic practices, climate, variety, regulations, and trading practices. As the competitive environment in the international wheat market intensifies, differentiation of wheat by quality characteristics has become increasingly important. In the period prior to 1973/74, price differentials in international markets were relatively small, likely reflecting the supply/demand situation and the lack of distinguishing differences in value among different classes of wheat. Since then, price differentials have increased in nearly all markets, reflecting increased differentiation in the international market. Notable increases have occurred in stronger wheat prices (HRS and CWRS) relative to all other classes. Of particular interest is that the relative increase in CWRS exceeded that of HRS.

Implicit values of certain quality characteristics are of interest. First, there is an implied value for spring-planted wheats relative to winter, at least at the higher protein levels, even while holding other factors constant. Second, there are substantial implicit premiums for Canadian wheat. Third, the implicit premium for hard wheats over soft has been diminishing in recent years. Fourth, the implied value of protein has been stable in some markets but has been gradually increasing in the past decade in the CIF Japan market. Caution must be exercised in interpreting these results. Care was taken in this study to select data from a reliable series in which locational and other differences were eliminated. As a result of this disaggregation, there were a limited number of wheat types traded at some markets, thereby precluding the ability to separate some effects (e.g., color) that were implicitly lumped with other characteristics (e.g., soft, country).

The basic hypothesis of this study was that in the aggregate market for wheat, there is an implicit market for quality characteristics. This market is influenced by policies, institutions, agronomic practices, etc., all of which vary across exporting countries. These results confirm that over time differentiation has increased. This has important implications for competitive strategies of individual exporters as well as the nature of competition. If the market does not reflect quality differentials, the need for providing mechanisms for differentiation may be minimal. However, as price differentials increase, the importance of being capable of differentiating increases. Thus, given the nature of competition in the 1980s, providing mechanisms that allow differentiation of wheats has become an important component of international competition.

The results presented here introduce as many unresolved issues as they resolve. Confirmed is that over extended periods, there are significant implicit values for quality characteristics such as habit, hardness, protein, and country of origin. The latter reflects a multitude of effects—the cumulative impact of the production/marketing system in each country as well as institutions, policies, and trade practices. There are at least two nagging issues. One is a comparison of the costs of constraints on variety release (e.g., Carter et al.) and other regulations imposed on a system versus the benefit of particular constraints and regulations. The other is that, whereas country of origin seems to be important, it is yet unclear which of the multitude of country-specific characteristics potentially contribute to these implicit values.

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