RURAL ECONOMY

STAFF PAPER

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The Values of Characteristics of Wheat in World Markets:
Some Further Evidence

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Staff Paper 90-09

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1 Introduction

Research on the values of characteristics in world wheat markets reported earlier applied the theory of the derived demand for characteristics of different wheats by wheat processors (Veeman, 1987). Estimates were reported of marginal values of the characteristics of wheat protein content and colour based on annual average f.o.b. export price data for major wheats from the United States, Canada, and Australia (Veeman, 1987). Marginal implicit prices for protein had varied somewhat over time and amounted to an average 0.5% price premium for a one percentage increase in protein (about US $6 per tonne of wheat) over the early 1980s. In the light of the general nature of the inverse relationship between yield and protein content that applies in breeding wheat (believed, following Tipples (1984) and Canada Grains Council (1982), to involve a reduction of about 10% or more in yield for a one percentage increase in protein), it was concluded that there is potential to increase total revenue from Canadian wheat exports from more emphasis on the development of higher yielding wheats adapted to the higher-moisture areas of the Prairies. The earlier study also found an appreciable marginal implicit value for white wheats, which received a price premium of nearly US $16 per tonne relative to red-coloured wheats in the early 1980s. The lack of geographic consistency necessarily inherent in the use of f.o.b. data for different export locations did not enable unambiguous conclusions to be drawn regarding any premiums or discounts associated with country of origin.

This note reports on an extension of the earlier analysis. The theory of consumers' demand for characteristics is applied and estimates of the marginal values of wheat characteristics including, where possible, protein content, colour, and country of origin are derived based on the published monthly c.i.f. data series from the International Wheat Council for the three different markets of Japan, Rotterdam, and the United Kingdom. Analysis of these data gives evidence on premiums or discounts associated with the country of origin of various wheats in these markets as well as further evidence on the levels and any changes in protein premiums and premiums or discounts associated with kernel colour.

2 Characteristics of Wheat Desired by Users and Choice of Variables[1]

Protein content (together with associated but less readily measured protein quality features) is a major characteristic of wheat that affects end-use performance and the characteristics of resulting consumer products. Kernel colour is another characteristic of importance to some users and consumers. There may also be consistent differences between wheat from different origins, other than protein and kernel colour. For example there are differences between countries in the nature and rigour of application of grading standards that may affect buyers' views of quality and its consistency. In Canada, an

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[1] For further detail, see Veeman, 1987.

institutional structure has developed that exerts strong controls over the licensing of grain and the maintenance of rigorous grading standards. Emphasis has traditionally been placed on achieving relatively high levels of protein. Licensing of Western Canadian grains requires visually distinguishable varietal identification between classes. This may heighten buyers' confidence in the application of grain grading standards, but has involved some limitations on breeders' ability to achieve yield increases. Varietal identification, achieved through a system of affidavits rather than visual identifiability, is also a requirement of the Australian wheat grading system in which segregation of classes and high grading standards also contribute to relatively uniform quality within classes. In contrast, grading standards and their maintenance have been criticized for U.S. wheat and there has been discussion of policy alternatives to enhance grain quality (Congress of the United States, 1989).

Importers' preferences for different wheats based upon the country of origin may relate to other factors than national differences in characteristics associated with grading. For example, there are some consistent differences in moisture content of wheat from different areas. In Canada and the U.S., harvesting occurs in periods of relatively high moisture content and consequently harvested grain is moister than in Australia; this may be a negative attribute for some importers particularly if storage in hot humid conditions is likely. However, in the earlier study, statistical findings did not justify inclusion of moisture of wheat as a separate variable. Users' familiarity with and preferences for wheat from specific counties or the sales procedures used by specific export agencies might also contribute to country of origin being a characteristic of importance to users. Overall, a combination of factors reflecting quality and locational factors, as well as institutional and political factors may be the basis of preferences for wheats from different national origins.

3 Theoretical Basis of the Demand for Characteristics

Following Gorman (1956, 1980) and Lancaster (1966) the approach used here assumes that consumers gain utility from the consumption of the particular characteristics or attributes (such as protein content or colour) of wheat and that goods (different wheats) incorporating these attributes are purchased in order to obtain desired levels of characteristics. The previous paper was based on the theory of processors' derived demand for characteristics. The more widely used approach, outlined here, of consumers' demand for characteristics was first used for farm products by Ladd and Suvannunt (1976). It yields a similar general estimating equation to the derived demand approach. Separability of the consumer's utility function is assumed and the arguments of this function are the characteristics in question:

$$U = U(z_1, \ldots z_n) \tag{1}$$

where z_i, $i = 1 \ldots n$, represents the level of characteristic i contributing to the consumer's index of utility. Characteristics are only obtained through the purchase of different goods, Y_j, $j = 1 \ldots m$, each of which contains particular bundles of objectively measured

characteristics. Thus $z_i = \sum_{j=1}^{m} z_{ij}$ where z_{ij} depicts the level of characteristic i in the jth good. The level of each characteristic which is available to the consumer is a function of the quantities of the various goods purchased by the consumer and the quantities of the characteristics contained in unit quantities of each of those goods. Purchase of goods at given prices (P_j, $j = 1...m$) is constrained by the available budget (M) allocated for this purpose so:

$$M \le \sum_{j=1}^{m} P_j Y_j \qquad (2)$$

The problem of utility maximization involving maximization of U subject to the budget constraint is solved by maximization of the Lagrangean function L where:

$$L = U(z_1,...z_n) + \lambda\left(M - \sum_{j=1}^{m} P_j Y_j\right) \qquad (3)$$

This yields first order conditions of:

$$\partial L / \partial Y_j = (\partial U / \partial z_i)(\partial z_i / \partial Y_j) - \lambda P_j = 0 \qquad j = 1,...m \qquad (4)$$

and

$$\partial L / \partial \lambda = M - \sum_{j=1}^{m} P_j Y_j = 0 \qquad (5)$$

since

$$\lambda = \partial U / \partial M, \qquad (6)$$

Solving equations (4) for P_j yields:

$$P_j = \sum_{j=1}^{m} (\partial z_i / \partial Y_j)(\partial M / \partial z_i) \qquad (7)$$

where: $\partial z_i / \partial Y_j$ is the marginal yield of the ith characteristic from the jth good (e.g. the protein content of a particular wheat); and $\partial M / \partial z_i$ depicts the marginal implicit value of the ith characteristic.

From information on the market prices of different wheats and the marginal yields of the different characteristics of these, estimates of the marginal implicit values of the characteristics are derived from (7) using regression techniques. As in other studies of the demand for product characteristics, it is assumed that this demand function is relatively stable during the periods studied and that changes in prices and quantities of characteristics in these periods arise from shifts in the supplies of characteristics rather than in the demand for them. This does not seem an unreasonable characterization of behaviour in world wheat markets over the time periods studied here. Consumption and import patterns have gradually changed over the past three or four decades, as was outlined above, accompanied

by changes in the pattern of production of different types of wheat; in the shorter-run periods considered in this study, variations in marketed quantities and prices seem to have been primarily generated by supply shifts resulting from changes in weather, technology, and national agricultural policies.[2]

4 The Data

Reflecting some of the structural characteristics of world wheat markets, c.i.f. prices are reported only for relatively few markets. The price data are monthly c.i.f. prices reported by the International Wheat Council in *World Wheat Statistics* for various wheats in each of the three markets of Japan, Rotterdam, and the U.K. (Tilbury). Some limitations are attached to each of these data series and must be kept in mind in analysing them. Specifically, in Japan, quantitative restrictions on wheat imports are associated with the domestic price supports for this grain and are administered by the Japanese Food Agency. Import quotas are allocated to millers and processors based on past purchases.[3] The Japanese market absorbed some 7 percent of world wheat imports in 1985/86. For this market, monthly c.i.f. import prices in U.S. dollars per tonne were collected for two Australian wheats (Prime Hard 13% protein and Australia Standard White) one Canadian wheat (No. 1 Canada Western Red Spring 13.5%) and four United States wheats (No. 2 Dark Northern Spring 14%; No. 2 Hard Winter 13%; No. 2 Hard Winter Ordinary; and No. 2 Western White). These data series enable colour and country of origin as well as protein content to be analysed for the three exporting nations of the United States, Canada, and Australia.

The import price data for Tilbury give a very limited view of world wheat markets. This is particularly so for recent years during which the European Community has shifted from being a major wheat import market to be a major source of lower protein wheat exports and a minor importer of high protein wheats for blending and for use by smaller bakers. It appears that import prices are affected by and reflect administration of domestic price support procedures. Nonetheless, this market was included in the analysis since it was once an important wheat import market and analysis of it may shed light on the impact of EC grains policy on import prices of different wheats. Less concern relates to the use of the Rotterdam price data since this is from a major grain trading market and trans-shipment port. For Tilbury, data were available for one Canadian wheat (No. 1 Canada Western Red Spring, varying protein content), EEC wheat (Milling) and two U.S. wheats (Dark Northern Spring 14% and 15%). These data, reported in pounds per long ton, were converted to U.S. dollars per metric tonne using the exchange rates reported by the IMF in *International Financial Statistics*. The series do not allow analysis of both colour and country of origin. Consequently, colour is omitted from this section of the analysis.

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2 Except, perhaps, for the UK (Tilbury) market.

3 The Agency sets domestic prices, maintaining relatively high producer prices and lower consumer prices.

The price data for Rotterdam are in U.S. dollars per metric tonne and include wheat from Canada and the United States. These series are for No. 1 Canada Western Red Spring (varying protein levels) and four U.S. wheats (No. 2 Dark Northern Spring 14%; No. 2 Dark Hard Winter 13.5%; No. 2 Hard Winter Ordinary; and No. 2 Soft Red Winter). All of these are red wheats, and thus colour can not be distinguished as a variable in the analysis for this market.

As with the earlier study, analysis of pooled cross sectional and time series data was necessary. The data and analysis cover the period from 1973/74 to 1985/86; the number of observations enable sub-periods within this time period to be analysed to assess the stability of the estimated relationships over time. However the data series do not represent a full set of consecutive observations since not all wheats were traded in each month. As discussed later, this creates difficulties for some desired statistical testing. Since moisture contents of the various wheats differ, the protein levels for each wheat were converted to their equivalent dry-matter basis.[4]

In order to account for any systematic trend in the data, and since monthly observations are involved, the impact of time on market prices is expressed as two components. The first is a time trend variable, and the second involves eleven monthly dummy variables to account for patterns of variation, such as seasonality, that may occur within years.

5 The Model, Estimation Procedures, and Results

The hedonic price model applied in this analysis is derived from Equation 7 and represented as:

$$P_{jt} = \sum_{j=1}^{m} \beta_{it} Z_{it} + e_t$$

where:

P_j denotes the monthly price in US dollars per tonne of Y_j, the jth wheat, $j = 1 \ldots m$, as discussed above; prices are deflated by the Organization of Economic Coordination and Development's all items consumer price index, 1981=100.

β_i denotes the estimated coefficient interpreted as $\partial M / \partial z_i$, the marginal implicit price of characteristic i;

Z_i denotes $\partial z_i / \partial Y_j$, the marginal yield of the ith characteristic from the jth wheat, $i = 1 \ldots n$, specifically:

Z_1 is dry-matter basis protein content percentage (expressed so 1=1%) of each wheat type;

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[4] Protein content was taken as by Veeman (1987); for EEC milling wheat, protein was taken to be 12% on a dry matter basis (based on Canadian International Grains Institute, 1982).

Z_2 is colour, with the value 0 for red wheats and 1 for white wheat in the Japanese market model version.

Z_3 and Z_4 denote the country of origin of each wheat. In both the Japan and Tilbury analysis, Z_3 denotes US wheat and Z_4 denotes Canadian wheat; thus estimated coefficients β_3 and β_4 express price impacts of these origins relative to the omitted category, which is Australian wheat in the Japan analysis and EEC milling wheat in the Tilbury analysis. For the Rotterdam analysis, Z_3 represents Canadian origin and the price impact is relative to US wheat.

Z_5 denotes a time trend starting at 1 for July 1973 and increasing in monthly unit increments until February 1986;

Z_6 to Z_{16} are monthly dummy variables for January to December, excluding June to avoid perfect collinearity; and

e_t denotes the error term.

The model is tested in both linear and partial semi-logarithmic form.[5] Both functional forms can be justified for hedonic price analysis. The linear function is consistent with Lancasters' (1966) specification of the characteristics demand model while partial semi-logarithmic models arise from Gorman's (1956, 1980) analysis (Muellbauer, 1974). The results, based on the use of ordinary least squares (OLS), for Japan, Rotterdam, and Tilbury are in Tables 1 to 3.

The use of OLS as the estimation procedure is appropriate for the model outlined here if there is no serial correlation in the disturbances for the various time periods and if the disturbances are independent, with constant variance. A preferred test of the appropriateness of OLS for this model is to apply Kmenta's cross-sectionally heteroscedastic and time-wise autoregression procedure as well as OLS and apply likelihood ratio tests of whether or not the structure of the disturbances would justify use of OLS.[6] However, for this analysis, the data series do not provide full sets of consecutive monthly price variables for all wheat types and thus autocorrelation in the disturbances cannot be tested for. It is assumed that there is no serial correlation in the disturbances over time and Kmenta's (1986) procedure for heteroscedasticity of the disturbance term across cross-sectional pooled observations is performed for Japan, the one market where data availability enabled this. The test could only be performed on that sub-sample of the data for this market for which there was a full set of cross-sectional observations.

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[5] In the latter, prices and percentage protein content are expressed in logarithmic form.

[6] These test procedures were followed in the earlier study and justified the use of OLS in that analysis.

The results of the tests, for the entire time period and two sub-periods, are summarized in Appendix Table 1. Except for the period 1980-81 to 1985-86, the tests indicate that heteroscedasticity does not present a problem. Heteroscedasticity-adjusted procedures developed by White, following Kmenta, were applied to the truncated data from Japan for 1980-81 to 1985-86; the results are in Appendix Table 2. The procedure does involve some disadvantages. The truncated sample data that must be used if Kmenta's procedure is to be used involves considerable data loss.[7] Due to loss of data, the heteroscedasticity-corrected procedure can only be applied to data from 1980-81 to 1985-86 rather than being applied to two separate time periods within this time frame. However indication of the structural change from 1980-81 to 1985-86 (Appendix 3) limits the reliability of the results reported in Appendix 2. Thus, while heteroscedasticity cannot be ruled out as a problem for data from 1980-81 to 1985-86, use of OLS applied to the full data set appears more appropriate. All estimations were carried out using version 6 of White's (1978) computer program.

In the previous study, covering 1976-77 to 1983-84, the data were subdivided into the two sub-periods of 1976-77 to 1979-80 and 1980-81 to 1983-84. The first of these periods was characterized by economic growth in much of the world and world trade grew relatively rapidly. Both these conditions changed in the second period. The time period in this analysis is expanded to 1973-74 to 1984-85 and the several sub-periods that are specified include those of the earlier study (to facilitate comparison of results from both studies) as well as earlier, and more recent periods (to extend the applicability over time of the analysis). Application of tests of structural change, outlined by Johnston (1984), following Chow, indicate such change has occurred over time in each market studied (see Appendix Table 3).

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7 Considerable information loss is involved in this sub-sample, for example, for the entire time period, only 560 of the total of 907 observations could be included.

Table 1

Estimates of the Hedonic Price Function for Wheat, Japan[a,b]

Equation Type	Intercept	Protein[c]	Colour	Time	US Origin	Canadian Origin	Adjusted[d] R^2	F-Statistic
			1973-74 to 1975-76					
Linear	247.83 (4.51)	10.80 (3.63)	28.98 (1.75)	-5.62 (-18.69)	9.50 (0.77)	25.61 (1.79)	0.74	36.20[e]
Semi-log	4.62 (9.83)	0.53 (3.35)	0.12 (1.76)	-0.16 (-10.50)	0.21 (3.94)	0.19 (3.58)	0.55	15.76[e]
			1976-77 to 1979-80					
Linear	42.86 (1.74)	5.44 (4.26)	14.12 (1.93)	1.06 (11.17)	5.59 (1.02)	22.22 (3.55)	0.40	13.32[e]
Semi-log	3.12 (10.66)	0.36 (4.01)	0.08 (1.95)	0.28 (9.61)	0.04 (1.23)	0.12 (3.53)	0.33	10.39[e]
			1980-81 to 1983-84					
Linear	280.90 (22.87)	5.48 (8.95)	8.65 (2.45)	-1.68 (-37.85)	3.24 (1.26)	19.52 (6.54)	0.87	117.88[e]
Semi-log	8.58 (57.11)	0.40 (10.67)	0.06 (3.31)	-0.96 (-43.87)	0.03 (2.21)	0.11 (7.76)	0.90	158.82[e]
			1984-85 to 1985-86					
Linear	197.94 (14.32)	4.17 (9.72)	7.11 (2.86)	-0.93 (-11.64)	5.52 (3.02)	21.26 (10.05)	0.85	48.23[e]
Semi-log	8.69 (19.58)	0.41 (9.53)	0.06 (3.09)	-1.00 (-11.58)	0.05 (3.45)	0.16 (9.71)	0.84	45.29[e]
			1973-74 to 1985-86					
Linear	224.40 (7.30)	5.83 (3.51)	10.81 (1.14)	-1.41 (-36.98)	8.55 (1.22)	21.08 (2.60)	0.61	90.09[e]
Semi-log	5.49 (23.64)	0.38 (4.90)	0.07 (1.89)	-0.30 (-45.90)	0.04 (1.44)	0.11 (3.84)	0.71	139.15[e]

[a] For brevity, the estimated coefficients for the monthly variables are omitted from the table.

[b] t-statistics are in brackets.

[c] Dry matter basis.

[d] Adjusted for degrees of freedom.

[e] Denotes F-statistics significant at the 99% level.

Table 2
Estimates of the Hedonic Price Function for Wheat, Rotterdam[a,b]

Equation Type	Intercept	Protein[c]	Time	Canadian Origin	Adjusted[d] R^2	F-Statistic
1973-74 to 1975-76						
Linear	117.09 (2.82)	16.57 (6.67)	-3.75 (-11.33)	20.77 (2.76)	0.78	29.43[e]
Semi-log	2.97 (8.26)	1.09 (8.54)	-0.10 (-6.62)	0.07 (2.33)	0.69	18.73[e]
1976-77 to 1979-80						
Linear	69.16 (4.66)	4.97 (5.32)	0.65 (5.48)	14.72 (3.51)	0.34	7.87[e]
Semi-log	3.46 (15.41)	0.40 (5.54)	0.17 (4.36)	0.08 (3.24)	0.30	6.61[e]
1980-81 to 1983-84						
Linear	291.95 (26.30)	4.56 (8.43)	-1.88 -25.14)	11.57 (3.41)	0.82	50.05[e]
Semi-log	9.40 (45.31)	0.44 (11.40)	-1.19 (-28.88)	0.08 (4.39)	0.86	66.94[e]
1984-85 to 1985-86						
Linear	236.45 (12.47)	3.48 (10.55)	-1.20 (-9.56)	10.41 (4.79)	0.86	21.33[e]
Semi-log	10.95 (14.13)	0.40 (10.44)	-1.47 (-9.50)	0.08 (4.33)	0.86	20.70[e]
1973-74 to 1985-86						
Linear	175.34 (9.95)	7.63 (7.03)	-1.28 (-27.37)	13.77 (2.54)	0.65	67.00[e]
Semi-log	5.16 (29.65)	0.49 (8.12)	-0.31 (-31.56)	0.04 (1.61)	0.71	90.10[e]

[a] For brevity, the estimated coefficients for the monthly variables are omitted from the table.

[b] t-statistics are in brackets.

[c] Dry matter basis.

[d] Adjusted for degrees of freedom.

[e] Denotes F-statistics significant at the 99% level.

Table 3

Estimates of the Hedonic Price Function for Wheat, Tilbury[a,b]

Equation Type	Intercept	Protein[c]	Time	US Origin	Canadian Origin	Adjusted[d] R^2	F-Statistic
1973-74 to 1975-76							
Linear	-284.02 (-1.83)	49.50 (3.87)	-4.50 (-15.43)	-89.10 (-1.91)	-53.05 (-1.14)	0.83	43.31[e]
Semi-log	-1.45 (-0.78)	2.92 (3.91)	-0.15 (-10.36)	-0.47 (-2.33)	-0.35 (-1.76)	0.76	27.49[e]
1976-77 to 1979-80							
Linear	573.65 (3.77)	-33.40 (-2.61)	1.10 (7.63)	86.52 (1.76)	92.27 (1.98)	0.51	11.06[e]
Semi-log	10.19 (4.36)	-2.32 (-2.42)	0.26 (6.47)	0.45 (1.71)	0.49 (1.93)	0.46	9.35[e]
1980-81 to 1985-86							
Linear	551.29 (7.76)	-8.57 (-1.45)	-2.25 (-25.04)	9.33 (0.03)	16.43 (0.76)	0.84	49.38[e]
Semi-log	12.64 (12.59)	-0.36 (-0.89)	-1.38 (-32.77)	-0.02 (-0.17)	0.04 (0.36)	0.90	83.51[e]
1973-74 to 1985-86							
Linear	155.89 (1.65)	12.91 (1.62)	-1.40 (-19.26)	-51.85 (-1.58)	-29.40 (-1.00)	0.51	29.66[e]
Semi-log	6.21 (5.29)	0.02 (0.05)	-0.23 (-20.49)	0.01 (0.10)	0.04 (0.31)	0.54	33.62[e]

[a] For brevity, the estimated coefficients for the monthly variables are omitted from the table.

[b] t-statistics are in brackets.

[c] Dry matter basis.

[d] Adjusted for degrees of freedom.

[e] Denotes F-statistics significant at the 99% level.

6 Discussion of Results and Their Implications

The Japanese wheat import market analysis (Table 1) demonstrates significant estimates of protein premiums; these were somewhat higher in the earlier 1970s than in the later 1970s; they appear to have increased somewhat in the early 1980s (to somewhat lower levels than in the early 1970s) and to have fallen again slightly in the mid 1980s. Overall, they are reasonably consistent with the earlier estimates based on f.o.b. export price data (Veeman, 1987). For the latest time period analysed (1984-86) there was an average premium of US $4.17 for a one percentage increase in protein (expressed on a dry-matter basis). This represented an average 0.4% price premium.

The estimated coefficient on the time variable is also significant and indicates falling real import prices of wheat except during 1976-77 to 1979-80. The coefficients on the seasonal dummy variables (not reported in the tables) have significant coefficients in many, but not all instances. There is an evident pattern of seasonality with import prices in September to February (and in April) tending to be higher than in other months. As in the earlier analysis of world export price data, the estimated parameter on the colour variable exhibits higher levels of significance in the more recent periods of analysis; in contrast to the earlier analysis, the estimated parameter on this variable for Japan is lower in more recent years than in the earlier years of study. White wheat received a premium of US $7 over red wheat in the mid-1980s.

The coefficients on the country of origin variables indicate that in the Japanese wheat import market over the time periods considered, Canadian wheat has obtained a substantial price premium relative to both U.S. and Australian wheat while U.S. wheat has received a more minor premium relative to Australian wheat. Over the most recent period of analysis, the premium for Canadian wheat approximated US $21 per metric tonne relative to Australian wheat and US $16 relative to American wheats; US wheat received a premium of nearly US $6 over Australian wheat.

The estimates for the Rotterdam market, in Table 2, indicate generally similar results for protein. Premiums appear to have been slightly higher in the earlier 1970s, subsequently to have fallen, then increased somewhat in the mid-1980s. Since the mid-1970s, protein premiums have been slightly lower, but generally consistent with those in the Japanese import market. The coefficients on the time variable show a similar pattern of change to Japanese import prices. Seasonality is also evident, with prices in August to February tending to be higher than in other months. Wheat of Canadian origin tended to receive consistent premiums over U.S. wheat. These premiums averaged US $10 per tonne in the

mid-1980s. The explanatory power of the model is lower in the later 1970s than in the other periods tested; levels of R^2 doubled when the model was tested on nominal price data for this period.[8]

The results of the analysis of UK import prices (Tilbury) must be treated with considerable caution as they represent a dwindling market largely influenced by the EC's grain policy and programs. In contrast to the other analyses, the results reported in Table 3 do not indicate significant positive protein premiums, except in the earlier 1970s. While few of the estimated coefficients are significant (none in the most recent sub-periods) it appears that since the mid-1970s, protein content has been subject to price discounts in the U.K. import market for wheat. It seems likely that this reflects the Common Agricultural Policy regulatory procedures that support wheat prices within the EEC. Apparently these procedures tend to penalize more the importation of higher protein higher priced wheats. The coefficients on country of origin are likely also related to the institutional framework for support of agriculture in the EEC. In the earlier 1970s, discounts applied for wheat originating from Canada, and even larger discounts were indicated for wheat from the U.S., relative to EEC milling wheat. This situation apparently was reversed in the later 1970s but the coefficients are not significant for the analysis for early to mid-1980. The estimated coefficients on the time variable are similar to those for the other markets and there is some evidence of a pattern of seasonality in prices that is similar to Rotterdam prices.

Overall, from the data for the Japanese and Rotterdam import markets, the study does provide evidence and estimates of premiums associated with Canadian country of origin, for white rather than red wheat, and for protein content. The premium for white wheat of $7 per tonne in the Japanese market during the mid-1980s is about half that estimated in the earlier study, based on f.o.b. prices. It may be that white kernelled wheat is less preferred in Japan than in other important segments of the world wheat market (for example, in the Middle East, North Africa, and India, where milling to very high extraction rates is common). The results outlined here indicate that protein premiums have fluctuated. Overall, however, there are indications that the premiums have tended to decline over time. This is consistent with the changes in features of world market demand for wheat that have occurred over time, including changes in milling and baking technology that made possible the substitution of lower protein wheat in pan bread production; the more recent feature of gluten supplementation; the increasing consumption of cookies, biscuits, and crackers that utilize medium and lower-protein wheats; and the growing importance of middle-income nations in world wheat markets.

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[8] The feature of a higher level of explanation of the model when tested on nominal rather than real price data also held for the Japanese and Tilbury import markets in the later 1970s. Money illusion during a time period of rapid inflation might explain this feature. For all three markets, the linear model versions appear to fit the data slightly better than the semi-logarithmic versions in the earlier years of analysis; the converse appears to be the case in the more recent time periods.

As found in the earlier study, protein premiums appear to be modest, relative to the sacrifice in yield that breeding for higher protein wheats entails. This is an implication also of the results reported by Wilson (1989) from his somewhat different model of implicit values of characteristics of wheat based, in part, on c.i.f. data for Japan and Rotterdam.[9] This feature again leads to the conclusion that more emphasis on development of higher yielding wheat is warranted, a conclusion that is also reached by Ulrich and Furtan (1984) and Carter *et al* (1986). While revenue gains from expanded production and export of 3-M-type wheats are also evident from the analysis by Henning and Martin (1989), the magnitude of these gains are questioned by these authors. Henning and Martin correctly note the high levels of competition that apply in world markets for lower value lower protein wheat. However, their analysis assumes that all areas of the prairies are equally suited to the production of CWRS wheats. This is not the case. Although high protein wheats are agronomically well suited to the arid areas of the prairies, they are not well suited to the moister prairie regions (particularly the black and grey soil zones) which tend to produce high proportions of lower grading CWRS wheat. Conversely, the yield potential of higher yielding varieties can be expected to be highest in higher-moisture conditions. Thus, development of agronomically improved higher yielding wheats is particularly important for the moister prairie regions. The development and licensing of high protein wheats was the traditional focus of the regulatory institutions associated with this industry and there is continued emphasis on protein levels. Development of high-yielding white wheats suited for Western Canadian growing conditions has lagged. The first such wheat (HY 355) has been registered although this new variety is not recommended for the black and grey soil zones (Canadian Wheat Board, 1989). Large segments of the Western Canadian wheat sector are likely to continue to specialize in the production of high protein wheats in the future, but emphasis on developing high-yielding and white kernelled wheats will increase production alternatives and revenues, particularly for farmers in the moister prairie areas.

7 References

Buse, A. 1973. "Goodness of Fit in Generalized Least Squares Estimation." *The American Statistician* 27: 106-108.

Canada Grains Council. 1982. *Grain Grading for Efficiency and Profit.* A Report Submitted by the Grain Grading Committee, Canada Grains Council, Winnipeg, September.

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[9] Wilson omits colour as a characteristic and takes a somewhat different approach than here in identifying hard versus soft wheats, and spring versus winter wheats as alternate characteristics. He considers protein content to be a relevant characteristic of hard wheats only. There are similarities in many of the results of the study by Wilson and those reported here but comparison is complicated by differences in the models. One difference in results is Wilson's finding of a price premium for Australian over US wheat in the Japanese market; this seems to arise from the differences in the treatment of colour which Wilson did not include as a characteristic for this market (in his study Australian wheat was the only white wheat considered).

Appendix Table 1

Likelihood Ratio Test Comparing Two Estimators on Truncated Data Set, Japanese Market[a]

Equation Type	Likelihood Ratios[b]		
	1973-74 to 1985-86	1973-74 to 1979-80	1980-81 to 1985-86
Linear	0.32	0.28	20.2
Semi-log	2.28	1.26	15.6

[a] The test compares OLS, viewed as the restricted model, with Kmenta's cross-sectionally heteroscedastic procedure for pooled data, viewed as the unrestricted model.

[b] In each case except for 1980-81 to 1985-86, the test statistic is less than the critical value of X^2 (i.e. 12.59) at the 95% level of significance, indicating appropriateness of OLS.

Appendix Table 2

Heteroscedasticity-corrected Estimates of the Hedonic Price Function for Wheat, Japan[a,b]

Equation Type	Intercept	Protein[c]	Color	1980-81 to 1985-86 Time	US Origin	Canadian Origin	Buse[d] R^2	F-Statistic
Linear	265.64 (24.49)	5.16 (9.05)	9.07 (2.77)	-1.52 (-47.30)	4.51 (2.01)	21.36 (6.74)	0.94	274.17[e]
Semi-log	8.90 (60.14)	0.41 (10.22)	0.06 (2.97)	-1.03 (-53.45)	0.04 (2.76)	0.13 (8.18)	0.95	386.68[e]

[a] For brevity, the estimated coefficients for the monthly variables are omitted from the table.

[b] t-statistics are in brackets.

[c] Dry matter basis.

[d] Buse-adjusted R^2.

[e] Denotes F-statistics significant at the 99% level.

Appendix Table 3

Tests of Structural Change in the Model Among the Periods 1973-74 to 1975-76, 1976-77 to 1979-80, 1980-81 to 1983-84 and 1984-85 to 1985-86

Regions:	Japan	F-statistics[a] Rotterdam	Tilbury[b]
Equation Type:			
Deflated prices, linear	63.6	36.40	69.77
Deflated prices, partial semi-log	33.1	23.01	54.61

[a] In each case, the calculated F-statistic exceeds the critical level at the 99% level of significance, indicating rejection of the null hypothesis that the regressions for all periods are the same.

[b] Due to data limitations, the observations for 1980-81 to 1983-84 and 1984-85 to 1985-86 were combined into one sub-period for this region.