Japanese Demand for Wheat Characteristics: A Market Share Approach

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This research took from the work of Kohli and Morey in the economics literature to apply a quality derived market share demand function to the international wheat market. Specifically, a Japanese wheat import demand market share model was derived using data for Hard Red Winter, Hard Red Spring, Canadian Western Red Spring, and Australian Standard White wheat. Results indicate that the four wheat classes analyzed here are relatively good substitutes for each other, the own-price elasticity for each wheat class is elastic, and the own-characteristic Protein elasticity for Hard Red Winter 13% protein wheat increased over the period analyzed.

Keywords: Wheat Quality Characteristics, International Wheat Demand, Market Share

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Numerous previous researchers have investigated international demand for commodity quality characteristics, e.g., Lin and Leath; Stiegert and Blanc; Uri et al. However, little attention has been given to how the demand for a commodity from one exporter is affected by a change in the quality of a commodity exported by another exporter. Wilson (1989, 1994) and Wilson and Preszler provide discussion on the importance of country of origin in determining international wheat prices, but only Stiegert and Blanc have comprehensively analyzed why the price differentials exist. The international wheat market is characterized by a quality differentiated market system where market share is dependent on not only price, but quality. The blending of heterogeneous wheat classes into a homogeneous product makes assessing the implicit value of product attributes particularly important. As an example, an important question by U.S. exporters of wheat to Japan is, what happens to Japanese demand for U.S. Hard Red Winter wheat should the level of protein in Canadian Hard Red Spring wheat exported to Japan increase, i.e., increased due to a high protein crop or the Canadian Wheat Board enforcement of a minimum protein level? More importantly, what are the costs to the domestic wheat marketing system from imposing quality restrictions. We propose to use the Kohli and Morey methodology where the relative market share of a commodity is specified as a function of the level of characteristics and the price of the commodity. Applying this methodology to the Japanese wheat import market we estimate own- and cross- characteristic elasticities to begin to answer the questions posed above. The objective of this research is to estimate wheat characteristic demand elasticities, separated by exporter, to the Japanese market.

Generally, a hedonic model is used to assess the marginal implicit value of the commodity's characteristics being imported. The hedonic model assumes the price paid/received is a function of the characteristics of the commodity. The hedonic model specification for agricultural commodities is based on exogenous supply and the demand for the commodity is derived from the sum of the characteristic level multiplied by the implicit premium or discount for the desired (or undesired) trait. Occasionally, market demand factors are considered in the hedonic model to account for exogenous factors, e.g., Parcell and Stiegert (1998, JARE) include in the hedonic model of the Hard Red Winter wheat the average protein level of Hard Red Spring wheat to account for regional protein competition in the blending process. The ultimate objective is estimation of demand elasticities for quality characteristics where no known market for the characteristic exists. Parcell and Stiegert (1998, AAEA selected paper annual meetings) have extended the traditional first-stage hedonic model (estimating the marginal implicit prices) using the Rosen approach to estimate demand elasticities for Hard Red Winter and Hard Red Spring wheat characteristics. However, application to international markets, where market share is an important factor, lend well to the Kohli and Morey methodology of estimating characteristic elasticities.

The procedures presented in this study are a first step in designing a comprehensive market share demand model that can be used to assess the change in Japanese demand for wheat, by export location, from a change in another exporter's wheat quality attributes. Such information is useful to public policy makers in assessing the costs of implementing quality restrictions on domestic exports of wheat.

Conceptual Model

The conceptual model used to estimate characteristic elasticities for Japanese wheat imports follows from the work of Kohli and Morey. Japanese wheat demand by country of origin is found by maximizing the following function:

(1) $$\max_X G(X, L) : E = PX,$$

where, G(▪) is a twice differentiable, increasing, and strictly quasi-concave in X, aggregator function, E is expenditures, $X = [x_i ; i = 1, \ldots, I]$ is the quantity of wheat imports from country i, P = [p_i ; i = 1, . . ., I] is the price of wheat imports from country i, and L = [l_{ki} ; k = 1, . . ., K and i = 1, . . ., I] is the level of wheat characteristic k imported from country i. The constant elasticity of substitution (CES) functional form is used to approximate the aggregator function because it is relatively simple to estimate and allows for the incorporation of wheat characteristics into the model.[1]

(2) $$G(X,L) = \left[\sum_i y_i^{\beta} h(l_{1j},...,l_{ij},.....,l_{Kj}) \right]^{\frac{1}{\beta}},$$

where h(•) is specified using the exponential form,

(3) $$h(l_{1j},...,l_{kj},.....,l_{Kj}) = \exp\left(\lambda_0 + \sum_k \lambda_k l_{ki} \right)$$

Substituting equations (2) and (3) into equation (1) and forming the dual, the maximization solution of equation (1) can be expressed in share form, employing Shepard's Lemma, as:

(4) $$s_i = \frac{x_i}{\sum_i x_i} = \frac{\left[\frac{h(i)}{p_i}\right]^{\sigma}}{\sum_j \left[\frac{h(j)}{p_j}\right]^{\sigma}} = \frac{\left[\exp(\sum_k \sigma\lambda_k l_{ki}) \Big/ p_i^{\sigma}\right]}{\left[\exp(\sum_k \sigma\lambda_k l_{kj}) \Big/ p_j^{\sigma}\right]}$$

where, σ equal to (1/1-β) and is defined as the Allen constant elasticity of substitution parameter, s_i is the market share from the i^{th} country in the Japanese wheat import market; h(i) and h(j) are vectors of quality characteristics (specified by $\exp(\sum_k \sigma\, \alpha_k l_{ki})$, where k is a vector of quality characteristics) from exporter i and all other exporters ($\sum_j$); and p_i and p_j is the price paid for wheat by Japanese importers. From equation (4) the own and cross price elasticities are calculated as:

[1] Clearly, a limitation of this study is the choice of such a restrictive functional form.

(5) $$\varepsilon_{ij} = \frac{\partial \ln s_i}{\partial \ln p_j} = \begin{cases} -\sigma(1-s_i) < 0 & i = j \\ \sigma v_i \stackrel{<}{>} 0 & i \neq j \end{cases}$$

where ε_{ij} is the own- or cross-price elasticity of demand derived. Similarly, differentiation of equation (4) with respect to characteristic k yields quality characteristic demand elasticities to assess own- and cross-characteristic effects from a change in quality:

(6) $$\eta^{l}_{ij} = \frac{\partial \ln s_i}{\partial \ln l_{ki}} = \{ \quad -\lambda_k l_{kj} \varepsilon_{ij}$$

Estimation Procedures and Data

Following the specification of equation (4) the Japanese import share model is specified using quality characteristics determined to be economically and statistically significant as reported by Stiegert and Blanc. These wheat quality characteristic variables are Ash, Color, and Protein. Wheat quantity, price, and quality data were collected for Canadian Western Red Spring, Australian Standard White, Hard Red Winter 13% protein, and Dark Northern Spring. Data covered the period 1984 through 1994. The data used in this study was the same as the data used by Stiegert and Blanc. Summary statistics are reported in table 1. Data used for this analysis were originally obtained from Japanese Food Agency and International Wheat Council. See Stiegert and Blanc for a complete discussion of the transformation of the data.

The system consists of four nonlinear market share equations. Note, these four equations are effectively estimated as one equation, however, because of cross-location correlation each equation is treated as separate. Since the market shares sum to one the variance-covariance matrix is singular and one equation must be dropped. Because the parameters are restricted across country of origin, there are five parameters estimated using a total of 44 observations (4 locations multiplied by 11 years).

Data were tested for the presence of a unit root using the augmented Dickey-Fuller test statistic. The presence of a unit root could be rejected for any of the series, therefore, all data were first-differenced and the test-statistic was again computed. All of the first-differenced data was found to be of a stationary nature. Thus, 40 observations were used in the estimation of the market share equations (the first year was dropped due to first-differencing the data). Because trends may persist over time, even with the differentiated data, autocorrelation was accounted for by fitting the data to the appropriate value of *rho*. The computed *rho* used to transform the data was –0.305. The Japanese market share demand model was estimated in *Shazam* 8.0 using the non-linear option.

Results

The model expressed in equation (4) was estimated as a double-log model. Choosing this functional form allowed for the characteristics to be specified in linear form. It should be noted that the choice of functional form and model specification for this study was made on the four principles 1) the CES functional form allows for relative ease in estimation; 2) the approach does not require full information of all exporting countries, thus, inferences can be made about countries where data may not exist and inferences can be made for hypothetical situations[2]; 3) the model easily allows for the incorporation of quality characteristics; and 4) because quality characteristics are treated as having the same impact across location fewer observations are required to estimate the model.

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[2] Full information is not required because the model specification assumes that only a change in the level of quality characteristic leads to a change in market share.

The estimation results from estimating the non-linear Japanese wheat import market share demand model are reported in table 2. The explanatory variables explained 98% of the variation in the relative market share. Each of the parameter estimates reported in table 2 is statistically significant at the 1% level. The parameter estimates listed in table 2, along with the relative market share, are used in the computation of price and characteristic elasticities using equations (5) and (6). The elasticity of substitution estimate ($\sigma = 1.8893$) indicates that the four classes of wheat used for this research are fairly good substitutes for each other.

Table 3 reports the own- and cross-price point elasticity estimates of demand for Japanese wheat imports. The own- and cross-price elasticities have been fairly consistent over time. The exception would be that Hard Red Winter wheat has become more elastic over time while the other wheat classes have become slightly less elastic. Each of the own-price point elasticity estimates indicates that wheat is price elastic, i.e., a 1% increase in price causes the relative market share to decline by more than 1%. The cross-price elasticity estimates indicate the percentage change in all other wheat class market shares from a 1% price increase for the respective wheat class.

Table 4 is used to list the own- and cross-characteristic elasticities for Ash, Color, and Protein. Changes in the level of Ash and Color appear to have a more significant impact on market share than Protein. However, considerable less variability exists for Ash and Color relative to Protein. That is, it would be much more common to have a 10% change in protein content than Ash or Color content. The only noticeable difference among the report elasticities is that the Protein own-characteristic elasticity for Hard Red Spring wheat is elastic. Also, Figure 1 graphically depicts the trend over the period of this study in the own-characteristic elasticity for Canadian Western Red Spring wheat, Hard Red Spring wheat, and Hard Red Winter 13% protein wheat. Clearly, while the elasticity for each wheat class fluctuates over time, the protein own-characteristic elasticity for Hard Red Winter 13% protein wheat trended upward.

Discussion

This research took from the work of Kohli and Morey in the economics literature to apply a quality derived market share demand function to the international wheat market. Specifically, a Japanese wheat import demand market share model was derived using data for Hard Red Winter, Hard Red Spring, Canadian Western Red Spring, and Australian Standard White wheat. Results indicate that the four wheat classes analyzed here are relatively good substitutes for each other, the own-price elasticity for each wheat class is elastic, and the own-characteristic Protein elasticity for Hard Red Winter 13% protein wheat increased over the period analyzed.

Initial studies such as this should be clear in listing limitations of the study and future extensions. The limitations of this study are that the data has not been updated and an extremely restrictive functional form (CES) was chosen. Future extensions of this work include evaluating alternative functional forms, inclusion of a reputation variable to help explain market share, and simulation of results to the case of implemented export quality standards for the U.S. or other wheat exporting nations.

As international purchasers of U.S. products, wheat for this analysis, place more value on quality, U.S. merchandisers will need better information on how international markets, the Japanese market in this analysis, changes demand based on changes in quality from other locations. For instance, climate plays a large role in the quantity of protein content and the question that can be answered by this analysis is how would Japanese demand for U.S. wheat change from a change in the Canadian Western Red Spring wheat protein content due to drought. Similarly, the domestic and global costs associated with implementing quality standards.

References

International Wheat Council. *World Wheat Statistics*. London: International Wheat Council. Various issues, 1984-1992

Japanese Food Agency, Inspection Division. *Quality Survey of Imported Wheat Cargoes*. Tokyo: Japanese Food Agency, Various issues, 1984-92.

Stiegert, K., and J.P. Blanc. "Japanese Demand for Wheat Protein Quantity and Quality." *Journal of Agricultural and Resource Economics* 22(1997):104-119.

Kohli, U., and E.R. Morey. "Oil Characteristics and the U.S. Demand for Foreign Crude by Region of Origin." *Atlantic Economics Journal* 18(September 1990):55-67.

Kohli, U., and E.R. Morey. "U.S. Imports by Origin: A Characteristic Approach." *KYKLOS* 41(1988):51-74.

Lin, W., and M. Leath. "Costs and Benefits of Cleaning U.S. Wheat: Overview and Implications." *Ag. Econ. Rep. No.* 675, USDA, Economics Research Service, Commodity Economics Division, Washington DC, 1993.

Parcell, J.L., and K. Stiegert. "Competition for U.S. Hard Wheat Characteristics." *Journal of Agricultural and Resource Economics* 23(1998):140-54.

_____________. "Factors Affecting Wheat Protein Premiums." *American Journal of Agricultural Economics* 81(1999): 1292

SHAZAM. *Econometrics Computer Program Users Reference Manual, Version* 8.0. New York, NY: McGraw Hill, 1997.

Wilson, W.W. "Differentiation and Implicit Prices in Export Wheat Markets." *West. J. Agr. Econ.* 14(1989):67-77.

____________. "Demand for Wheat Classes by Pacific Rim Countries." *J. Agr. and Resour. Econ.* 19(1994):197-202.

Wilson, W. W., and T. Preszler. "Uncertainty and Competition in International Wheat Markets." *Amer. J. Agr. Econ.* 74(1992):556-63.

Uri, N.D., B. Hyberg, S.A. Mercier, and C. Lyford. "A Note on the Market Valuation of Grain Quality Characteristics." IJ. International Food and Agribusiness *Marketing* 6(1994):17-42

Figure 1. Protein Own-Characteristic Elasticity Between 1984 and 1994

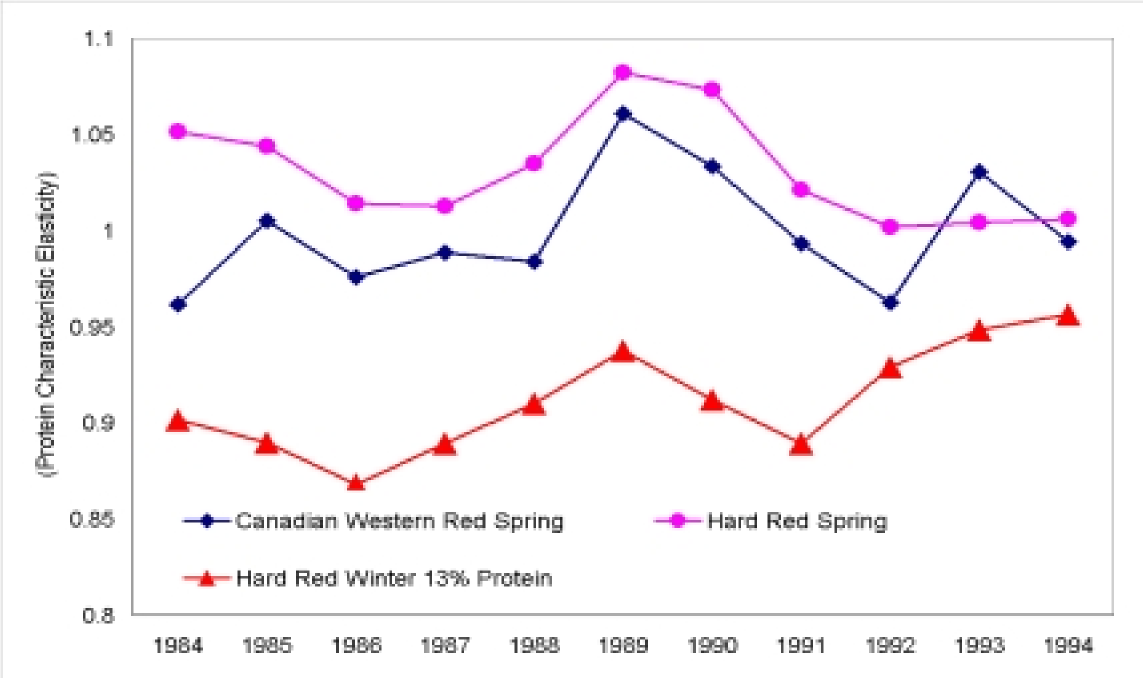

Table 1. Description of Variables and Summary Statistics of Data used in Estimation of Japanese Wheat Import by Origin Characteristic Demand Models.

Variable	Canadian Western Red Spring	Dark Northern Spring	Hard Red Winter 13.0%	Australian Standard White
Dependent Variable	204.02	185.46	179.46	167.62
Protein[a]	16.189	15.861	14.714	11.099
Ash	1.556	1.567	1.506	1.272
Color	79.85	79.23	78.92	81.23
Market Share	0.28	0.23	0.26	0.23

[a] Reported protein means have been adjusted to a dry matter basis.

Table 2. Parameter Estimates from Japanese Wheat Market Share Quality Demand Equation. Dependent Variables is Import Market Share of Wheat.

Variable	Parameter Estimate	*t*-statistic
Elasticity of Substitution (σ)	1.8893***	46.326
Ash	-1.2736***	10.562
Color	0.07400***	9.990
Protein	0.05637***	13.733
Intercept	0.03989***	11.638
R^2	0.986	
rho	-0.3025	
No. of observations	40	

Three asterisks (***) denote statistical significance at the 1% level

Table 3. Own– and Cross–Price Elasticity of Demand for Japanese Wheat Imports

	1986	1990	1994
	Own-Price Elasticity		
Canadian Western Red Spring	-1.361	-1.367	-1.365
Australian Standard White	-1.476	-1.424	-1.416
Hard Red Winter 13%	-1.359	-1.392	-1.472
Hard Red Spring	-1.472	-1.486	-1.415

	1986	1990	1994
	Cross-Price Elasticity		
Canadian Western Red Spring	0.528	0.522	0.524
Australian Standard White	0.414	0.466	0.474
Hard Red Winter 13%	0.530	0.497	0.417
Hard Red Spring	0.417	0.404	0.475

Table 4. Characteristic Own– and Cross–Characteristic Elasticity of Demand for Japanese Wheat Imports

	1986	1990	1994
	Own-Price Elasticity		
Canadian Western Red Spring			
Ash	-2.368	-2.493	-2.687
Color	6.334	6.393	6.335
Protein	0.976	1.033	0.994
Australian Standard White			
Ash	-2.249	-1.965	-2.259
Color	6.813	6.626	6.474
Protein	0.752	0.694	0.713
Hard Red Winter 13%			
Ash	-2.482	-2.522	-2.685
Color	6.176	6.324	6.526
Protein	0.868	0.912	0.956
Hard Red Spring			
Ash	-2.720	-2.780	-2.801
Color	7.015	7.002	6.407
Protein	1.014	1.073	1.006

	1986	1990	1994
	Cross-Price Elasticity		
Canadian Western Red Spring			
Ash	0.919	0.953	1.031
Color	-2.459	-2.443	-2.431
Protein	-0.379	-0.395	-0.338
Australian Standard White			
Ash	0.631	0.643	0.756
Color	-1.911	-2.168	-2.166
Protein	-0.211	-0.227	-0.239
Hard Red Winter 13%			
Ash	0.979	0.901	0.761
Color	-2.408	-2.260	-1.848
Protein	-0.338	-0.326	-0.271
Hard Red Spring			
Ash	0.771	0.756	0.939
Color	-1.988	-1.903	-2.149
Protein	-0.287	-0.292	-0.338