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QUALITY AND PRICE COMPETITION IN THE INTERNATIONAL WHEAT MARKET

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I. INTRODUCTION

In certain markets price differentials play an important role in the competition between sellers. The potential for price differentials to persist and be a sustainable competitive factor depends on significant quality differences. In the case of competition in the international wheat market price differentials between wheats of different exporters, as well as wheats from different U.S. origins, have become increasingly important in recent years (Wilson). Indeed, as the international competitive environment intensifies sellers around the world are increasingly examining the quality of their wheat offered to the international market (U.S. Congress, Office of Technology Assessment). Quality is a competitive factor and can be viewed simply as an inverted means of price competition i.e., offering a higher quality at the same price as a competitor is equivalent to lowering prices (Abbott). There are a multitude of institutions which exist in the marketing system of the individual exporters which provide mechanisms to affect the quality of grain exported, and therefore the use of quality as a competitive tool. Examples include variety development and release, breeding programs, controls over the marketing system, incentives versus regulations, grading systems and regulations over shiploading. Each of these can be influenced to various degrees and impact the end use performance of the exported grain.

Traditional approaches to the analysis of export demand use fairly aggregated data and/or empirical specifications which precludes assessing the role of quality and price in export competition. At best one can measure the elasticity of substitution between fairly aggregate wheats (i.e., where the country is represented by one type of wheat). However, even these are fraught with problems associated with price averages, quality specifications and other aggregation problems. In order to rigorously assess the role of quality in exporter competition, highly specific data are required. These include technical information on input (i.e. wheat) quality and product requirements, input and output prices and other relevant institutional details unique to individual importing countries.

In this study we develop the "Input Characteristics Model" (ICM) as originally advanced by Ladd and Martin to analyze the role of quality and price competition in a selected wheat import market. That market chosen is the United Kingdom which in the past had been a major importer of hard wheats from both the U.S. and Canada, the principal suppliers of this type of wheat. Though this may be termed a declining market it has a number of important characteristics to demonstrate the ICM. First, there has been vigorous competition between the two suppliers of imported wheat and Canada has gained market share--as we will show due to both price and quality considerations, but particularly the latter. Second, since joining the EC and concurrent escalation in domestic wheat prices, wheat production in the UK has increased drastically. However, the wheat produced in the UK is of a lesser quality. In order to assure a market for at least a portion of the domestic wheat production, restrictions are imposed on processors to use a certain portion of domestically produced wheats in their grists. Since the domestic produced wheat is of lesser quality this restriction has an impact on import demand for wheats of different origins. Finally, in the case of bread flour milling the

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UK is recognized as a leader in technology which eventually may be transferred to other parts of the world. In the first section below the ICM model is developed and described in the context of the UK wheat milling industry. The results and important conclusions are presented in the final section.

II. U.K. FLOUR MILLING AND THE INPUT CHARACTERISTICS MODEL

Ultimately wheat is used as an input for the production of flour and subsequently other processed products (e.g. bread, biscuits etc). Imported wheat can be used by itself, as a blend with other imported wheats, and/or as a blend with domestically produced wheat, and combinations of these are used to produce a multitude of products. The input characteristic model (ICM) was developed to account for inputs with different end use physical quality characteristics. Differences in yields of input characteristics affect processors since they impact their outputs and therefore profits. Differences in test weight for example affects the quantity of flour that can be milled from a bushel of wheat. The ICM model proceeds with a production function and associated profit function which is maximized. After various manipulations the results can be used to define the value of an input used in production. The purchase price of an input equals the sum of the marginal implicit prices of the input characteristics multiplied by the marginal yield of those characteristics. Implicit prices vary with the price of the output and the productivity of the characteristic. Or simply, the ICM implies the price paid for each input used in producing an output equals the sum of the money values of the inputs characteristics. Thus, the ICM implies that market prices for inputs vary due to certain characteristics which they possess. Ladd and Martin applied the ICM model to several different problems, one of which entailed adoption to a linear programming problem. It is this latter approach which is used below in the case of UK wheat flour milling to analyze import demand for wheats of different quality.

The ICM was developed for a typical UK wheat flour mill. Desired quality characteristics (i.e., quality specifications on outputs) for the products were obtained from personal interviews, as well as comparable extraction rates and relative prices. Performance data for various wheat inputs were obtained by conducting technical analysis on samples of five types of wheat. Two Canadian (CWRS 13.5% and 14.5%) and two U.S. hard red spring (HRS 14% and 15%) samples and one sample of English wheat were evaluated in the Cereal Chemistry department of North Dakota State University. The technical analysis specifically analyzes the blending potential of HRS and CWRS with wheat flour derived from English, French and German wheats. Results were used as technical coefficients in the ICM and are shown in Table 1.

Input prices for English wheat were obtained from commercial traders for the period in early 1987. For imported wheat prices data prior to early 1987 were evaluated to document the historical price relationships. Typically Canadian wheat at comparable protein levels were offered at a premium of up to 13$/mt over the like U.S. wheat. Another important feature affecting input prices for imported wheat in the UK is the impacts of the variable import levy. Historical data for each of these variables were examined to reconstruct typical relative prices for imported wheat for the initial solution. Output prices for mill products were obtained from commercial sources.

TABLE 1. PERTINENT QUALITY CHARACTERISTICS OF THE ENGLISH HRS AND CARS WHEAT AND FLOUR

	U.K.	HRS 14%	HRS 15%	CWRS 13.5%	CWRS 14.5%
<u>Wheat Data</u>					
Moisture (%)	14.0	11.8	11.4	11.4	11.0
Protein (%)	12.1	13.6	14.4	13.5	13.9
Ash (%)	1.44	1.49	1.58	1.48	1.43
Dockage (%)	.20	.20	.40	.20	.30
1000 Kernel Weight (g)	41.5	31.0	30.7	31.2	28.2
Extraction Rate (%)	81.3	76.1	75.8	73.2	73.3
<u>Flour Data</u>					
Protein (%)	10.8	12.8	13.7	12.8	13.3
Ash (%)	.43	.39	.43	.42	.39
Falling Number (sec.)	338	375	332	550	508
Farinograph Absorption (%)	57.5	59.1	60.1	62.5	62.5
Farinograph Peak Time (min.)	2.7	11.0	10.0	7.0	6.0
Farinograph Mix Tolerance (Min.)	4.7	25.0	18.0	16.5	16.0
Farinograph MTI (B.U.)	50.0	5.0	5.0	15.0	5.0
Farinograph Valorimeter	47.0	84.0	81.0	73.0	70.0
Loaf Volume (cc)	2400	3000	3200	3025	3150
Bread Score (100 is best)	40	91	99	89	96

The following notation is used in specification of the mathematical model: Z = the maximum dollar value of the objective function; C_i = the cost of the i^{th} wheat in U.S. dollars/MT; P = the sales price of the product in U.S. dollars/MT; X_i = the wheats used to mill straight grade flour; F_{ij} = the amount of straight grade flour milled from the i^{th} wheat; A_k = desired value of quality constraint; A_{ijk} = the value of the k^{th} quality characteristic of the j^{th} straight grade flour from the i^{th} wheat; B_{ij} = the yield of the j^{th} product from the i^{th} wheat; Y = the total amount of the product from the flour blend in percent; where: i = 1 . . . . . 5 wheats; j = 1 . . . . . 5 straight grade flours; and k = 1 . . . . . 8 quality characteristics. The following notation for wheat (i) and flour (j) lots was used: X_1 = CWRS 14.5; F_{11} = straight grade flour from X_1; X_2 = CWRS 13.5; F_{22} = straight grade flour from X_2; X_3 = HRS 15; F_{33} = straight grade flour from X_3. X_4 = HRS 14; F_{44} = straight grade flour from X_4; X_5 = English; F_{55} = straight grade flour from X_5.

The objective function is to maximize profits which are defined as the sum of the product sale minus the sum of the cost of each wheat:

$$\text{Maximize } Z = PY - \sum_{i=1}^{5} C_i X_i$$

Subject to:

$$F_{ij} = B_{ij} X_i$$

$$Y = \sum_{i=1}^{5} Y_{ij}$$

$$Y \geq = 25F_{55}$$

$$\sum_{i=1}^{5} A_{ijk}F_{ji} \geq A_kY \quad \text{or} \quad \sum_{i=1}^{5} A_{ijk}F_{ji} \leq A_kY$$

Three quantity constraints were used in the model. The first denotes the amount of straight grade flour yielded by each of the wheat: $F_{ij} = B_{ij}X_i$. The amount of the j^{th} straight grade flour from the i^{th} wheat is equal to the yield of the j^{th} flour for the i^{th} wheat times the amount of the i^{th} wheat milled. The second quantity constraint was a material balance or transfer equation required to add the total amount of each straight grade flour yielded by each individual wheat. This equation assures that the total of the five equals 100.0 so that the quantities of flours used to manufacture the product can be interpreted in terms of percentages. The transfer equation

is: $Y = \sum_{i=1}^{5} Yij$ and states that the quantity of the product is the sum of the

j^{th} product for the i^{th} wheat. A restriction was also placed on the amount of English straight grade flour to be used in the final blend. In personal interviews it was disclosed that company policy requires that at least 25 percent English flour must be used in the final flour blend. The quantity constraint enters the problem in the following manner: $Y \geq 25F_{55}$, indicating that the amount of F_{55} used in the final blend must be greater than or equal to 25 percent.

The fourth restriction indicates the sum of the j^{th} flour from the i^{th} wheat times the value of its quality characteristic must be less than, greater than or equal to the product times the value of the desired quality characteristic, dependent on the desired result of the restriction. For example, the flour protein quality constraint is:

$$10.8F_{11} + 13.0F_{22} + \ldots + 13.3F_{55} \leq 12.75Y$$

and

$$10.8F_{11} + 13.0F_{22} + \ldots + 13.3F_{55} \geq 12.25Y$$

The equation specifies that the weighted average protein content of the flour produced must be between 12.25 and 12.75 percent to meet product specifications. The other quality characteristic constraints are handled in a similar fashion.

$$\sum_{j=1}^{5} A_{ij2}F_{ji} \leq A_2Y$$ Flour ash (percent)

$$\sum_{j=1}^{5} A_{ij3}F_{ji} \geq A_3Y$$ Farinograph absorption

$$\sum_{j=1}^{5} A_{ij4}F_{ji} \geq A_4Y$$ Farinograph peak time

$$\sum_{j=1}^{5} A_{ij5}F_{ji} \geq A_5Y$$ Farinograph mix time (minutes)

$$\sum_{j=1}^{5} A_{ij6}F_{ji} \geq A_6Y$$ Loaf volume (cubic centimeters)

$$\sum_{j=1}^{5} A_{ij7}F_{ji} \geq A_7Y$$ Bread Score (units)

$$\sum_{j=1}^{5} A_{ij8}F_{ji} \geq A_8Y$$ Flour falling number (units)

Thus, the model determines how five different straight grade flours can be blended in various proportions to maximize profits subject to product specifications.

III. Empirical Results

The optimum solution for the blending problem is given in Table 2. The solution indicates the quantity of each wheat lot used in producing the final flour mix as well as the optimal amount of straight grade flours to be blended. For example, to make the flour blend 66.6 percent of CWRS 14.5 (X_1), 28.2 percent of HRS 15 (X_3), and 36.5 percent of wheat from the U.K. (X_5) are milled separately to yield the following amounts of straight grade flour: 48.9 percent of FF_{11}, 21.4 percent of F_{33}, and 29.7 percent of F_{55}. These percentages of flours are then blended together to produce the final mix. Differential extraction rates account for the differences in the flour quantity milled from the total wheat quantity used.

TABLE 2. OPTIMUM SOLUTION AND PRICES IN THE INITIAL FORMULATED

Wheat Lot	Price ($U.S./mt)	Total Wheat Quantity Used (%)	Wheat Extraction Rate (%)	Flour Lot	Optimum Flour Blend (%)	Price Range Lower Limit ------($/mt)	Price Range Upper Limit ------
CWRS 14.5	365.76	66.6	73.3	F_{11}	48.9	337.85	368.51
CWRS 13.5	353.44	0.0	73.2	F_{22}	0.0	337.85	a
HRS 15	357.49	28.2	75.8	F_{33}	21.4	343.88	368.36
HRS 14	341.84	0.0	76.1	F_{44}	0.0	329.76	a
UK	211.15	36.5	81.3	F_{55}	29.7	b	242.57

[a]No upper limit price shown since wheat lot not used in basis at current price.
[b]No lower limit price shown since minimum amount is already being used.

All of the straight grade flour specifications are satisfied by the solution of the model. Farinograph absorption and bread score are the quality characteristics exactly satisfied by the solution. The other quality characteristics are in excess of requirements. Since the quality characteristics of farinograph absorption and bread score are the only factors to exactly satisfy the solution, they are the only variables for which the solution provides a value range. Farinograph absorption can increase by .43 percent or decrease by 1.1 percent while bread score can increase two units or decrease five units without changing the optimal solution. Ranges for both variables are small, therefore, indicating the slight changes in their values would alter the optimal solution.

Marginal values are defined as the change in profit indicated by the value of the objective function due to a one-unit change in the quantity of a wheat or flour. Profit may increase or decrease, when a unit change in quantity is made dependent on the sign of the marginal value coefficient. Neither CWRS 13.5 (X_2) or HRS 14 (X_4) are milled for use in producing the final flour blend. Therefore, the marginal values for these wheats represent a reduction in the profit value if one metric ton was forced into the optimum solution. These results are shown in Table 3. For example, if one metric ton of CWRS 13.5 (X_2) was forced into the solution, profit would decrease by $3.08 and if one percent of F_{22} was forced into the final blend of straight grade flour, profit would decrease by $4.21. The shadow price for F_{22} would remain at the given value until the upper quantity level of 41.96 percent is attained

TABLE 3. MARGINAL VALUE COEFFICIENTS OF THE WHEAT AND FLOUR LOTS AND THE QUANTITY RANGES OVER WHICH THEY ARE APPLICABLE

Wheat Lot	Flour Lot	Marginal Value Coefficient	Quantity Range	
			Lower Limit	Upper Limit
CWRS 13.5		-$3.08		
HRS 14		-$12.08		
	F_{22}	-$4.21	0	41.96
	F_{44}	-$15.88	0	19.35

in the final blend. Interpretation of the values for HRS 14 (X_4) and flour F_{44} are similar.

Shadow or marginal implicit prices can also provide economic information for the evaluation of quality characteristics. The shadow price for farinograph absorption and bread score were -$15.04/mt and -$2.91/mt, respectively. These imputed prices are economic measures of the increase in inputs cost if an additional unit of the resource were available. For example, an additional percent of farinograph absorption would increase the cost of the wheat and thereby reducing profit by $15.04/mt. The marginal value for bread score is interpreted in the same manner. None of the other quality characteristics were in excess in the optimal solution and consequently, a shadow price of zero was imputed to them.

Despite that U.S. wheats had lower effective import price, they are used only minimally in the grist. The reason for this is largely due to farinograph absorption which was a limiting factor in all models. A simple interpretation of this characteristic is its ability to absorb water. Given the abnormally weak (i.e., low Farinograph at 57.5) indigenous UK wheat and given the end-use product specification, imported wheat with greater farinograph absorption (e.g., CWRS is 62.5) are preferred to lower (e.g., U.S. was 59 and 60 percent, respectively by 14% and 15% protein) at equal prices. Even at higher relative prices (up to a point as discussed below), CWRS will have a greater share of this market due to this (and other) technical requirements. Thus, this methodology is very useful in identifying critical quality parameters in import and exporter competition. However, by nature these will likely be unique to every market due to a multitude of reasons which are incorporated in this type of model.

A key parameter which is (or can be) used in affecting export competitiveness is that of pricing. Through the uses of selected export subsidies, or other pricing arrangements, exporters can determine the relative price level by which their wheats compete. However, in the context here adjustments in relative prices must account for the technical characteristics of both the inputs and outputs. To evaluate the impact of changes in prices, parametric programming was used to identify critical relative price levels at which substitution occurs. The model was re-run using different relative prices for CWRS 14.5%. These were specified as a ratio ranging from 1.0 to 1.10 and the results on factor utilization are shown in Figure 1. The results indicate that the base solution remains optimal up to the point where the import price ratio is 1.08. At that point lower protein wheats are substituted for the higher protein CWRS. It is of interest that historical data on prices suggest that the actual ratio is only slightly less than this critical ratio. Note, however, that this ratio is compounded in the complete analysis which includes the variable import levy in this market, the effect of which is to favor CWRS relative to the lower priced U.S. wheats.

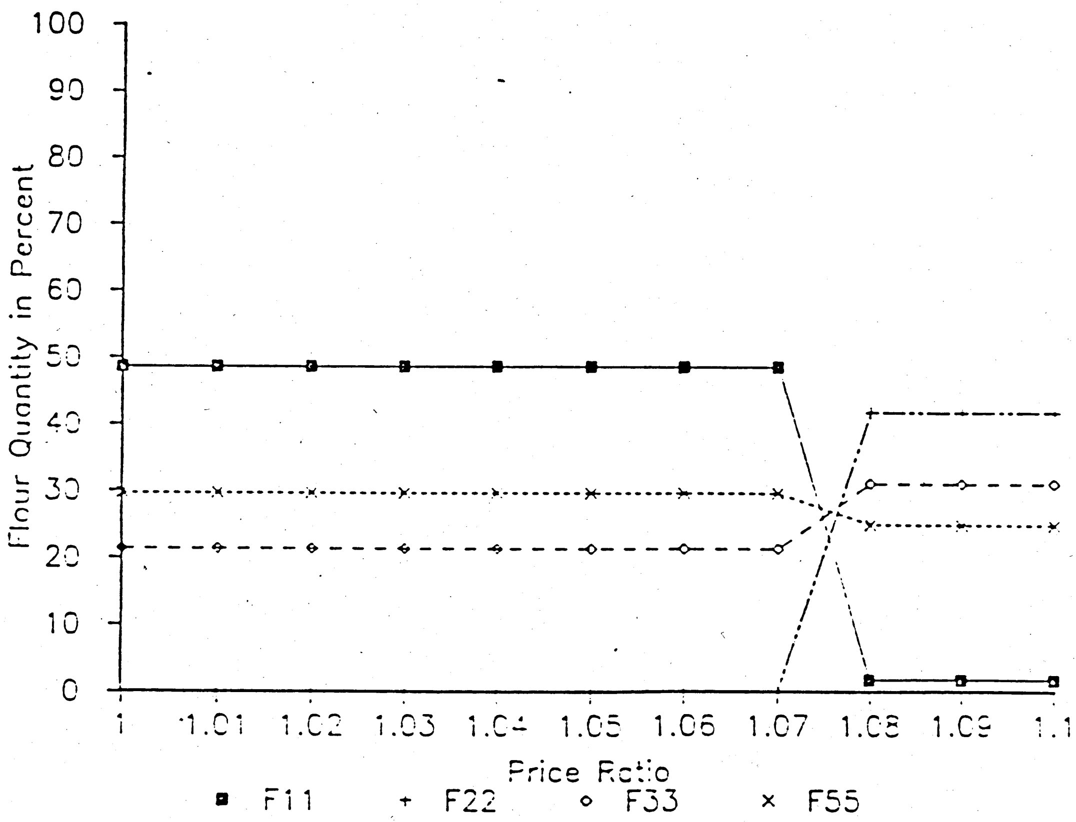

Figure 1. Factor Utilization Schedule for Straight Grade Flours.

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Re-examining the Importance of Exchange Rates to U.S. Farm Exports to Developing Countries

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The hypothesis that the value of the dollar matters to the level and prices of U.S. agricultural exports has received mixed empirical support, (for ex., 7, 9). One response to these findings has been to reevaluate the underlying methodologies employed, including the measurement of the effective dollar exchange rate (2, 5, 7). The purpose of this paper is add to this discussion the special perspective of developing countries, particularly the implications of their use of the U.S. dollar to denominate their primary product exports. The paper presents a simple model of how this characteristic causes changes in the value of the dollar to affect both the relative price of U.S. exports, and the income of developing countries through valuation changes in their dollar export earnings. Indices of real exchange rates which measure valuation changes, are calculated for 23 developing countries, and used to re-examine the significance of the value of the dollar for their commercial import demand for U.S. corn and wheat.

BACKGROUND

Developing countries have become an important and dependable export market for U.S. agriculture. In FY 1987, developing countries accounted for 40 percent of U.S. agricultural exports to the world. Sales to this market exhibited a relative stability during the 1980's when U.S. farm exports to the rest of the world fluctuated. Developing countries are a particularly important market for U.S. grains. Corn sales to developing countries rose from 20 percent to nearly 50 percent of total U.S. corn exports between 1981-87. Wheat sales to developing countries accounted for between 50 and 75 percent of U.S. world wheat exports during the same period. Wheat exports to developing countries fell in the mid-1980's, but not to the same degree as in other markets, thus helping to sustain U.S. wheat exports during