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Implicit Price Estimation of Rice Quality Attributes for Asian Americans

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ABSTRACT

Product placement survey data for 192 Asian-American households in Houston were used to analyze the value of rice quality attributes via the Consumer Goods Characteristics Model (CGCM). Five rice varieties were used for this study: domestic Lemont, Jasmine 85, Toro II, and two different Thai import varieties. For each variety, marginal implicit prices were calculated at the means for seven characteristics: color, texture, aroma, stickiness, flavor, aftertaste, and moisture.

Key Words: Asian Americans, Consumer Goods Characteristics Model, marginal implicit prices, quality characteristics.

Annual consumption of milled white rice for Asian Americans often exceeds 150 pounds per person (Tong), roughly nine times the 16.6 pounds per capita average (excluding usage for beer, processing, etc.) for the United States (Putnam and Allshore). Taste preferences for many Asian-American ethnic groups are for a long-grain aromatic rice variety with medium-grain cooking qualities similar to Thai Jasmine, as opposed to conventional long-grain varieties typically available in the U.S. (Goodwin et al.).

In 1994, over 220,000 metric tons of milled rice were imported into the United States to fill the market void resulting from unavailability of a satisfactory U.S. rice variety to meet the dietary preferences of the country's 7.3 million Asian Americans (population figure based on U.S. Department of Commerce/ Bureau of the Census 1990 data). Thailand accounts for more than 93% of those rice imports, with most being Jasmine or other aromatic types (Wailes and Livezey). The 1994 imports had an estimated retail value of $194 million based on prevailing prices and were equivalent to U.S. production from 114,000 acres, assuming field yields equivalent to U.S. commercial rice production experiences. Using the Texas Input-Output Model multipliers, the potential economic impact of the U.S. filling this imported rice market with a domestically produced and processed rice is over $500 million (Wildenthal).

The importance of such high levels of imported rice is being further emphasized by its

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appearance in traditional market channels such as non-Asian supermarkets (Rice Foundation). It has been estimated by some U.S. rice firms that as much as 30% of the U.S. white milled long-grain market is now comprised of imported aromatic rice, primarily from Thailand and presently consumed primarily by Asian Americans. As a response to this market threat, Jasmine 85, a domestic aromatic, was developed and introduced into Asian-American markets in the early 1990s. Such rice, however, has not received widespread acceptance in the Asian-American markets due to perceived quality differences (Goodwin et al.).

Consumers' market preferences should therefore be determined so that appropriate production and marketing decisions can be developed. The product characteristics demanded by Asian-American end users must be identified to facilitate development of appropriate varieties and technology processes necessary for realizing eventual profitable commercialization. The development and public release of a new variety such as Jasmine 85 is quite costly, often approaching $10–15 million and requiring at least seven years (Stansel). Accordingly, rice producers and processors are interested in capturing the characteristics of rice that will translate into high demand and profitable price levels for their products. Therefore, the primary objectives of this research were to: (*a*) identify key rice quality attributes affecting rice prices for aromatic and non-aromatic rice in the burgeoning Asian-American market segment, (*b*) estimate appropriate marginal implicit prices for specific quality attributes characteristic of these varieties, and (*c*) estimate a "base price" for these rice varieties and compare this price to the elicited subjective prices for these same varieties.

Theoretical Justification

The objectives of this research were to measure the effects of quality attribute levels contained in "packages" of various rice varieties and, therefore, their effects on the perceived values of rice varieties. The Consumer Goods Characteristics Model (CGCM), developed by Ladd and Suvannunt in 1976, seemed the logical model for this study. This model assumes that products are desired as a result of the unique bundle of characteristics each provides. The CGCM has been widely used in analyzing the values associated with various grades of agricultural commodities (Ladd and Suvannunt; Jordan et al.; Unnevehr; Eastwood, Brooker, and Terry; Chiou, Chen, and Capps). The basic premise of the CGCM is that utilities are derived from the characteristics that a product possesses. Hence, the total amount of utility a consumer enjoys from his/her purchases of products depends on the total amounts of product characteristics purchased. Consumers cannot buy the characteristics they need from the market; they can only buy the products which provide those characteristics.

Assuming there are m common characteristics provided by n different products, the total consumption of each quality characteristic is a function of the quantities of products consumed. In addition to these common characteristics, each product may offer the consumer a characteristic unique to that product. Magnitudes of the quality characteristics levels within each product unit are determined by producers' decisions involving varietal selection and cultural and handling practices. The price paid for a consumer good is the sum of the marginal values of the products' characteristics, where the marginal monetary value of each characteristic equals the quantity of the characteristic obtained from the marginal product unit consumed multiplied by the marginal implicit price of the characteristic.

Data

The data used in this study were obtained from results of a household survey published in 1992 by Goodwin et al. In total, 363 individual respondents from 259 households of Vietnamese, Chinese, Taiwanese, Thai, Filipino, and Cambodian ethnic groups were surveyed.[1]

[1] The preference of these six ethnic groups is typically for long-grain rice. Therefore, Japanese and Koreans are not included since their taste preference is traditionally for medium- or short-grain rice (USA Rice Council).

Table 1. Definitions for Maximum and Minimum Values of Rice Attributes

Attribute	Value = 1	Value = 9
Color	Brown/yellow; not desirable	Very white; very desirable
Texture	Soft; not desirable	Hard, very desirable
Aroma	No aroma; not desirable	Very aromatic; very desirable
Stickiness	Not sticky; not desirable	Sticky; very desirable
Flavor	No flavor; not desirable	Very flavorful; very desirable
Aftertaste	No aftertaste; not desirable	Much aftertaste; very desirable
Moisture	Dry; not desirable	Wet; very desirable

Note: Attribute values were ranked on a Likert scale of 1–9.

Five rice varieties, consisting of one new domestic aromatic (Jasmine 85), two U.S. nonaromatics (Lemont, a standard U.S. long grain, and Toro II, a southern long grain with medium-grain cooking characteristics), and two types of imported Thai Jasmine, were evaluated by survey respondents on the quality attributes of color, texture, aroma, stickiness, flavor, aftertaste, and moisture. These attributes were identified as being the most important during one-on-one interviews and in focus groups among Asian Americans.

The seven attributes were evaluated on a Likert scale from 1 to 9, with 1 indicating little presence of the attribute and low desirability, and 9 indicating a relative abundance of the attribute and high desirability (table 1). Both level and desirability (preference) of the attributes present were evaluated by respondents. Although these measures were subjective evaluations, buyers based their purchase behavior on desirability of an attribute's level and not the level itself. As a result, desirability ratings were selected for use in the analysis. The mean values for each characteristic of the rice samples are listed in table 2.

It is important to recognize that desirability levels provided by the respondents correspond to their preferences for each specific attribute in each variety evaluated, and may not necessarily be comparable across varieties. Preference for an attribute across varieties may be

Table 2. Mean Values and Standard Deviations for Rice Attributes for Five Varieties

	Variety				
Attribute	Lemont	Jasmine 85	Toro II	Thai I	Thai II
Color	6.3412	5.9010	6.2021	6.3458	6.7876
	(1.4272)	(1.5653)	(1.3000)	(1.4413)	(1.3326)
Texture	5.2588	5.7426	5.6702	6.0000	5.9823
	(1.6630)	(1.5978)	(1.6223)	(1.4537)	(1.4453)
Aroma	4.7882	5.0297	5.2553	5.5794	5.2920
	(1.8067)	(1.8410)	(1.5094)	(1.7377)	(1.8930)
Stickiness	4.6706	5.1980	5.2553	5.6355	5.1858
	(1.6503)	(1.7551)	(1.5306)	(1.5443)	(1.6177)
Flavor	4.8941	5.1980	5.0745	5.5794	5.4602
	(1.5662)	(1.7494)	(1.5743)	(1.6428)	(1.7930)
Aftertaste	4.8588	4.9604	5.0745	5.3645	5.4425
	(1.6195)	(1.7083)	(1.4386)	(1.5805)	(1.7624)
Moisture	4.9294	5.3762	5.2872	5.5607	5.4602
	(1.6020)	(1.6903)	(1.5071)	(1.4353)	(1.5529)
No. Observations	85	101	94	107	113

Note: Numbers in parentheses are standard deviations.

determined by the presence of distinctive determinants of the attribute within each variety, and not necessarily the level of the attribute. For example, one would expect texture, stickiness, and moisture to be comparable across varieties, whereas aroma, flavor, and aftertaste may possess properties unique to an individual variety.

Each rice variety has its own unique aroma and flavor characteristics based upon the intensity of various aromatic oils, volatiles, and chemical compounds present (or absent). This is partially determined by genetic coding of each variety and partially by cultural and handling practices of each rice evaluated. In contrast, texture, moisture, and stickiness are comparable across varieties, despite the fact that these attributes are also uniquely determined. It is rather like comparing the intensity of color in red wines and ranking them in terms of "redness," despite the fact that their unique "bouquets" and "flavors" cannot be compared in such a manner.

Prices for each of the rice varieties were not directly observed due to the experimental nature of the rice evaluated.[2] Jasmine 85, a newly developed variety, had not been introduced in the marketplace, and therefore no "marketplace" price existed. Lemont and Toro II, although they are existing domestic varieties, do not have an actual marketplace price because the U.S. rice industry does not typically offer rice of a single or "pure" variety to consumers. The Thai I and Thai II varieties used in this study were representative of Thai imports currently in the marketplace.

To account for the absence of directly observed prices, a price variable for each of the five varieties was derived by adjusting the price paid per pound by respondents for the rice they currently use. Adjustments were calculated based upon subjective statements relating the premium or discount that would be paid for each rice variety evaluated in comparison with the rice currently consumed. Choices for premiums and discounts ranged (in $1 increments) from +$3 per 25 pounds to −$3 per 25 pounds. Respondents could also state they would pay the same price for the sample rice as that being paid for the rice they currently used. The "price" (consumer's willingness to pay) for a specific type of rice was calculated on a one-pound basis by adding the price of the rice currently consumed and the premium/discount related in the survey.

In developing the price estimates described in the preceding discussion, an underlying assumption was that the quantity of rice consumed by the household responding would not change. Assuming total utility is additive, a compensating variation construct may be employed to illustrate a consumer's susceptibility to a "bribe" through price discounts. This allows the purchase of an equal amount of alternative rice varieties in place of the variety currently consumed. Under this assumption, the total utility derived from consuming an alternative rice variety could be lower than that derived from their current rice. The price discount necessary to persuade the consumption of "inferior" rice would be treated as surplus income to be spent on other goods. In this manner, the purchase of other goods would return total utility to its original level. A similar construct may be made for price premiums where the added utility from consuming a premium rice would be offset by lower utility derived from other expenditures.

Procedure

Following established procedures (Ladd and Suvannunt; Jordan et al.; Unnevehr; Eastwood, Brookwood, and Terry; Chiou, Chen, and Capps), price for rice was modeled as follows:

$$(1) \qquad P_t = f_t(x_{t1}, x_{t2}, \ldots, x_{t7}),$$

where P_t is the price for rice variety t that a household was willing to pay, and $x_{t1}, x_{t2}, \ldots, x_{t7}$ represent seven rice attributes (color, texture, aroma, stickiness, flavor, aftertaste, and moisture) of variety t. Linear and quadratic functional forms, among others, were consid-

[2] Goodwin et al. randomly dispersed the variety samples to the participating households over five weeks, using clear polyethylene bags. No rice purchases were associated with the study.

ered for estimating the implicit prices of rice quality characteristics. A linear form,

$$(2) \qquad P_t = \alpha_t + \sum_{i=1}^{7} \beta_{ti} X_{ti},$$

assumes that the implicit price for each characteristic is fixed, or does not change as the amount of characteristic changes. Consequently, the marginal implicit price of the ith attribute for variety t is β_{ti} for the entire range of x_t. The quadratic functional form,

$$(3) \qquad P_t = \alpha_t + \sum_{i=1}^{7} \beta_{ti} X_{ti} + \sum_{i=1}^{7} \sum_{j=1}^{7} \gamma_{tij} X_i X_j,$$

$$\text{for } i, j = 1, 2, \ldots, 7,$$

suggests a U-shaped/inverted U-shaped relationship between rice characteristics and rice price. As a result, the marginal implicit prices, such as the marginal implicit price of the attribute i of variety t, are

$$(4) \qquad MIP_{ti} = \beta_{ti} + 2\gamma_{tii} X_i + \sum_{j=1}^{6} \gamma_{tij} X_{tj},$$

$$\text{for } j \neq i,$$

and the change rate for marginal implicit price is $2\gamma_{tii}$. Because the participants in this study stated that each attribute has an optimal level that may be assigned a point value of less than 9 on the Likert scale, the quadratic was selected for the analyses.

A separate equation was estimated for each of the five rice types. The choice to estimate single-equation models for each variety rather than utilizing a series of dummy variables to identify varietal differences was predicated on the overall objectives, which were to identify and estimate the "value" each attribute contributes to the price of the variety. The attributes are contained in various bundles with respect to the variety in which they were present, and to the desirability of these attributes in relation to each bundle. Estimating the model utilizing a dummy variable approach for varieties would ascribe price differentials to varieties and not to attributes within varieties.

A pooled analysis of all five varieties using slope shifters is possible, but was not utilized for several reasons. First, variables such as *FLAVOR* and *AROMA* refer to flavors and aromas specific to each variety, not differing levels of common attributes across varieties. Second, the addition of slope shifters would not only increase the number of right-hand-side variables by a factor of four, but also would introduce a potential collinearity problem across varieties. Third, there are enough observations for each variety that the gains in degrees of freedom from a pooled analysis would have minimal effects on the statistical significance of estimated parameters. Thus, separate equations for each variety were utilized to achieve the goals of this research endeavor.

In addition to the quality characteristics identified as being significant to Asian Americans in their selections of rice, dummy variables representing the ethnicity of the participants were used in the estimations. To test the structural significance of these dummy variables, models were run for each of the five varieties with and without these dummy variables. *F*-tests were used to determine the additional variance explanation provided by the ethnic dummy variables. From these test results, it was determined that ethnicity played a significant role in the purchase and consumption decisions for the Lemont, Toro II, and Thai II varieties. Because the *F*-tests showed no significant differences between the purchase decision of the ethnic groups for the Jasmine 85 and Thai I varieties, the results shown for those varieties are taken from the estimations in which the ethnic dummy variables were not used.

OLS results indicated the presence of significant heteroskedasticity based upon the White test (Kmenta); therefore, weighted least squares (WLS) was employed for model estimation. Initial OLS estimates also indicated a significant presence of multicollinearity among specific regressors. Ridge regression (Hoerl and Kennard; Kmenta) was employed to adjust for multicollinearity rather than other

approaches such as bundling of characteristics or indexing, due to the importance of each variable present in the model. From a structural aspect, the tradeoff of some injected bias was preferred over loss of information on individual attributes and their effect on price. Several values of k were used for estimation; $k = 0.1$ was selected for use in this analysis. As the ridge coefficient becomes larger, the amount of bias introduced into parameter estimates increases. However, some small amount of bias must be accepted in order to reduce the large amount of variance and obtain efficient estimators. WLS results of the quadratic functional form are presented in table 3. Log and semi-log functional forms were also estimated and found to yield statistically inferior results to those of the quadratic form.

Results

A priori, certain hypotheses related to each attribute were formulated. For color, texture, stickiness, and moisture, these hypotheses were specific to desirability level irrespective of the type of attribute, and are listed below.

- *Color:* White is preferred.
- *Texture:* Softer is preferred to firmer rice.
- *Stickiness:* Sticky is preferred to separate rice.
- *Moisture:* Moist is preferred to dry rice.

However, such one-dimensional hypotheses were not possible for aroma, flavor, and aftertaste, because any of these attributes may be judged desirable or undesirable within each variety. The aroma or flavor of a rice may be considered objectionable. Consequently, a *decrease* in that attribute might be desirable. Conversely, if the aroma or flavor were considered favorable, an *increase* in that attribute might be desirable. A similar result for desirability would be obtained even though the assessment of decreased or increased presence of the attribute by the households differed. Because of this complexity, and due to the lack of prior research of this nature, no a priori hypotheses were made regarding aroma, flavor, or aftertaste.

Estimated coefficients from these analyses are presented, along with their respective t-statistics, in table 3. As is typically the case with household surveys, R-squares were extremely low. Inspection of these results revealed that parameter estimates found to be statistically different from zero varied considerably among varieties. Estimated prices for the varieties evaluated were determined based upon an assessment by households of an expected bundle of characteristics (attributes) in each good (rice variety). The differing significant characteristics among the five rice varieties add further credence to the assertion that rice is not considered to be a homogeneous commodity by Asian-American consumers (Goodwin, Holcomb, and Rister).

Recalling that a primary objective of this research was to assess the acceptability (as measured by price) of various rice varieties by Asian-American consumers, a variety-by-variety overview of each result would be beneficial. For Lemont, generally considered a standard domestic long-grain variety, texture had a negative and statistically significant effect on the price participants were willing to pay, and the interaction term of texture-stickiness had a significantly negative effect on the price of Lemont rice. The coefficient estimate for the Filipino ethnic dummy variable was statistically significant and positive, indicating that the price Filipinos would pay for Lemont was greater than that of Chinese consumers.

The coefficient associated with the squared term for aroma in Jasmine 85 had a positive value, indicating that the respondents of the household placement study would pay for additional aroma in Jasmine 85. However, the linear term was negative and insignificant. Although Jasmine 85 rice was developed as a U.S. alternative to aromatic Thai rices, the resulting aroma apparently varies enough from Thai imports to discourage Asian-American consumers from demanding this variety. Jasmine 85 also retained more moisture than was desired by the participants, and thus this attribute was judged to have a negative impact on price.

The analysis of Toro II rice revealed a textural difference associated with this variety that was very desirable to households sur-

veyed. Additional units of firmness were shown to add to the price of Toro II. Stickiness had a negative impact on price when considered as a primary effect, but the interaction of this variety's stickiness with its color and moisture appealed to the desires of the consumers in a positive manner. Stickiness is a trait traditionally desired by rice consumers of Asian origin. The ethnic coefficient for the group consisting of Southeast Asians indicates this group positively affected the willingness to pay of participants.

The analysis of the Thai I variety showed statistical significance of the coefficient for the square of flavor, suggesting that at its mean, the flavor of this variety was not at the level deemed optimal by the consumers, i.e., more flavor is desirable. The association of color to perceived flavor was also statistically significant in the decision of participants to pay more for this rice variety. The statistical significance of the interaction of texture and stickiness further supports the contemporary beliefs that Asian Americans prefer firmer, sticky rice to softer, or non-sticky rice.

The coefficient for aroma in the Thai II variety indicated an undesirable aroma. However, the significant coefficient for the square of aroma indicates that a more desirable aroma in this variety would increase the willingness to pay of Asian-American consumers for this particular rice. Stickiness positively affected price, but texture and aftertaste both had negative impacts on price. Results of this analysis suggest that the interaction terms of texture with color and aroma were positive aspects; the interactions of stickiness with color and texture did not meet the expectations or desires of the consumers and these characteristics were already perceived to be negative in comparison to the Thai rice the respondents currently consume. The significance of the ethnic coefficients indicate that for this Thai sample, each of the four ethnic groups expressed different willingness-to-pay levels, with Filipinos and Southeast Asians willing to pay more than Chinese, and the Taiwan group willing to pay less.

Marginal Implicit Prices

Estimated coefficients in table 3 were used to calculate implicit prices for attributes based upon responses of the sample households. A positive implicit price indicates the willingness to pay for one more level of an attribute, and a negative implicit price indicates the willingness to pay for removing one level of an attribute. Since the quadratic functional form was used in this study, the implicit prices are linear functions of the attributes' level. The marginal implicit price (MIP) of the ith attribute for variety t was calculated as shown in equation (4). The rate of change in the marginal implicit price was $2\gamma_{iit}$. These marginal implicit prices and their respective rates of change were calculated at the means by variety for each of the seven characteristics and are presented in table 4.

From the calculated marginal implicit prices for Lemont, it seems that the aroma, texture, moisture, and aftertaste of this American long-grain variety have a negative impact upon the willingness of Asian Americans to purchase this rice. The aftertaste level of this variety had the greatest negative impact on its perceived value at $-0.8¢$ per pound. Color, stickiness, and flavor had positive MIPs, with flavor having the greatest effect on price per pound at $+1.7¢$. Color was a close second at $+1.3¢$ per pound.

The Jasmine 85 variety had negative MIPs for aroma, stickiness, and moisture. Moisture had the largest negative implicit price at $-1.0¢$ per pound. Of the positive MIPs calculated for color, texture, flavor, and aftertaste, aftertaste had the highest implicit price at $+1.3¢$ per pound. The relatively firm texture of Jasmine 85 resulted in an implicit price for this attribute of $+1.1¢$ per pound.

Unlike Lemont, Toro II had an undesirable stickiness level, resulting in an MIP of $-3.7¢$ per pound. Participants also disliked the flavor and aftertaste of this variety, resulting in MIPs of $-2.1¢$ and $-2.0¢$ per pound, respectively. Positive MIPs were calculated for aroma, texture, and moisture. Texture had a high MIP of $+2.4¢$ per pound, and preference for the aro-

Table 3. Parameter Estimates for Rice Quality Attributes

	Variety				
Attribute	Lemont	Jasmine 85	Toro II	Thai I	Thai II
Color	−0.02078	−0.00166	0.03370	0.00617	−0.07306
	(−0.2753)	(−0.1820)	(0.3496)	(0.8514)	(−0.8868)
Color × Color	0.00949	0.00023	−0.00618	0.00023	0.00357
	(1.121)	(0.3235)	(−0.6884)	(0.3877)	(0.5816)
Aroma	0.00919	−0.00784	−0.00807	0.00193	−0.12953
	(0.1752)	(−1.231)	(−0.0764)	(0.2802)	(−1.911)*
Aroma × Aroma	0.00332	0.00131	0.00221	0.00049	0.01446
	(0.7526)	(1.628)*	(0.2864)	(0.6688)	(3.423)*
Stickiness	0.07297	−0.00506	−0.19726	0.01166	0.20340
	(0.8153)	(−0.7051)	(−1.931)*	(1.404)	(2.581)*
Stickiness × Stickiness	0.01150	−0.00061	−0.00478	0.00067	−0.00426
	(0.6252)	(−0.7884)	(−0.5161)	(0.8163)	(−0.9591)
Texture	0.03842	0.00477	0.25617	−0.00142	0.04376
	(0.4917)	(0.6206)	(2.461)*	(−0.1863)	(0.5444)
Texture × Texture	−0.01038	0.00447	0.02474	−0.00013	−0.01540
	(−1.967)*	(0.8519)	(2.193)*	(−0.1920)	(−2.487)*
Moisture	−0.03457	−0.01281	−0.05802	0.00648	0.00666
	(−0.3988)	(−1.706)*	(−0.6386)	(0.7610)	(0.0894)
Moisture × Moisture	0.01040	0.00017	−0.00684	−0.00020	−0.00487
	(0.8584)	(0.2723)	(−0.8627)	(−0.2496)	(−0.7994)
Flavor	0.10072	−0.00111	−0.01928	0.00615	−0.02501
	(1.217)	(−0.1630)	(−0.1299)	(0.7568)	(−0.3939)
Flavor × Flavor	0.01030	0.00030	−0.00524	0.00136	0.00351
	(0.9569)	(0.4268)	(−0.7083)	(1.724)*	(0.6211)
Aftertaste	−0.10281	−0.01016	−0.01910	−0.00530	−0.10698
	(−1.056)	(−1.468)	(−0.1854)	(−0.7065)	(−2.053)*
Aftertaste × Aftertaste	0.00331	0.00019	−0.00058	0.00087	−0.00404
	(0.4253)	(0.2654)	(−0.0530)	(1.097)	(0.8965)
Color × Texture	0.00959	−0.00010	−0.01551	−0.00022	0.01716
	(1.129)	(−0.1574)	(−1.255)	(−0.2930)	(2.142)*
Color × Aroma	−0.01133	−0.00079	0.00608	−0.00031	−0.00549
	(−1.512)	(−1.059)	(0.5261)	(−0.3841)	(−0.8001)
Color × Stickiness	0.00537	0.00033	0.02660	0.00056	−0.01875
	(0.3965)	(0.4252)	(1.945)*	(0.7928)	(−1.879)*
Color × Flavor	−0.01495	−0.00000	0.00685	0.00135	0.01418
	(−0.8673)	(−0.4907)	(0.4657)	(1.819)*	(1.603)
Color × Aftertaste	0.00117	0.00146	−0.00801	−0.00035	0.00087
	(0.0736)	(1.614)	(−0.6817)	(−0.4290)	(0.1243)
Color × Moisture	−0.00813	−0.00042	−0.00730	0.00041	−0.00561
	(−0.4342)	(−0.6011)	(−0.6669)	(0.6660)	(−0.6157)
Texture × Aroma	0.01511	−0.00062	−0.00799	−0.00106	0.01926
	(1.709)*	(−0.8124)	(−0.4996)	(−1.206)	(2.031)*
Texture × Stickiness	−0.03062	0.00034	−0.03064	−0.00164	−0.01577
	(−2.125)*	(0.4885)	(−1.594)	(−1.779)*	(−1.850)*
Texture × Flavor	−0.00322	0.00034	−0.00772	0.00062	−0.00852
	(−0.3424)	(0.4386)	(−0.6646)	(0.8750)	(−0.9305)

Table 3. (Continued)

	Variety				
Attribute	Lemont	Jasmine 85	Toro II	Thai I	Thai II
Texture × Aftertaste	0.01086	0.00035	−0.00294	0.00049	0.00847
	(0.9550)	(0.5009)	(−0.1561)	(0.5418)	(1.102)
Texture × Moisture	0.00820	−0.00002	−0.03009	0.00029	0.00304
	(0.6280)	(−0.4538)	(−1.795)*	(0.3791)	(0.3205)
Aroma × Stickiness	−0.00698	0.00134	−0.00490	0.00046	−0.01191
	(−0.7614)	(1.604)	(−0.4669)	(0.4770)	(−1.771)*
Aroma × Flavor	−0.00422	−0.00089	−0.00721	0.00015	−0.01199
	(−0.3180)	(−1.124)	(−0.8454)	(0.1689)	(−1.919)*
Aroma × Aftertaste	0.00105	0.00052	−0.00228	−0.00102	0.00486
	(0.1034)	(0.6800)	(−0.1577)	(−1.269)	(0.8402)
Aroma × Moisture	−0.00067	−0.00050	0.01552	−0.00117	0.00156
	(−0.0558)	(−0.5975)	(1.094)	(−0.7815)	(0.1783)
Stickiness × Flavor	0.01746	−0.00053	−0.00583	−0.00015	0.00109
	(1.006)	(−0.5111)	(−0.5810)	(−0.1680)	(0.2056)
Stickiness × Aftertaste	−0.01752	0.00044	0.10365	−0.00086	0.00456
	(−0.8802)	(0.5200)	(0.9127)	(−1.009)	(0.7611)
Stickiness × Moisture	−0.00209	0.00000	0.03881	−0.00064	0.01751
	(−0.0960)	(0.8035)	(1.913)*	(−0.7383)	(1.799)*
Flavor × Aftertaste	−0.00069	0.00036	0.00554	0.00017	0.00545
	(−0.0499)	(0.4567)	(0.3580)	(0.2397)	(0.9360)
Flavor × Moisture	−0.02645	0.00046	0.01760	−0.00072	−0.00927
	(−1.733)*	(0.6716)	(1.512)	(−0.8772)	(−1.015)
Aftertaste × Moisture	0.01586	0.00065	−0.00307	−0.00052	0.00329
	(0.9671)	(0.314)	(−0.1482)	(−0.5552)	(0.4476)
Filipino (dummy)	0.07070	—	0.05627	—	0.06103
	(2.199)*		(1.489)		(2.259)*
Taiwan (dummy)	0.04207	—	−0.00119	—	−0.06778
	(0.5436)		(−0.0279)		(−1.991)*
SE Asian (dummy)	0.03365	—	0.07316	—	0.04630
	(0.9557)		(2.098)*		(1.907)*
Constant	0.06271	0.33341	0.31563	0.19199	0.53800
	(0.2102)	(4.371)*	(0.8850)	(2.268)*	(1.831)
Adjusted R^2	0.2657	0.1408	0.3630	0.2239	0.2336
No. Observations	85	101	94	107	113

Data Source: Asian-American Households Survey, Houston, TX (Goodwin et al., 1992).
Notes: Numbers in parentheses are *t*-statistics. An asterisk (*) denotes statistical significance of the parameter at the α = .10 level or greater.

ma of Toro II resulted in an estimated MIP of +1.6¢ per pound.

For the Thai I variety, negative MIPs of an absolute value greater than one cent per pound were calculated for aroma (−1.0¢) and texture (−1.2¢). The negative MIP for aroma is contrary to common beliefs concerning Asian rice preferences, and may represent some problem with the particular sample of rice used for this study. Moisture and aftertaste both had calculated MIPs of −0.8¢ per pound. In comparison to the other four varieties, the flavor at-

Table 4. Marginal Implicit Price for Rice Quality Attributes by Variety (¢/lb.)

	Variety				
Attribute	Lemont	Jasmine 85	Toro II	Thai I	Thai II
Color	1.3	0.3	−0.4	1.7	0.3
Aroma	−0.3	−0.1	1.6	−1.0	0.9
Stickiness	1.0	−0.1	−3.7	0.6	0.1
Texture	−0.3	1.1	2.4	−1.2	1.2
Moisture	−0.6	−1.0	1.3	−0.8	0.0
Flavor	1.7	0.1	−2.1	3.1	−2.0
Aftertaste	−0.8	1.3	−2.0	−0.8	0.3
	Changes in Marginal Implicit Prices ($2\gamma_{ni}$)				
Color	0.01898	0.00046	−0.01236	0.00045	0.00714
Aroma	0.00664	0.00262	0.00442	0.00097	0.02891*
Stickiness	0.02299	−0.00121	−0.00955	0.00133	−0.00852
Texture	−0.02076*	0.00089	0.04948*	−0.00026	−0.03079*
Moisture	0.02080	0.00034	−0.01368	−0.00039	−0.00975
Flavor	0.02060	0.00059	−0.01048	0.00271	0.00701
Aftertaste	0.00662	0.00038	−0.00116	0.00175	−0.00809

Note: An asterisk (*) denotes statistical significance at the $\alpha = .10$ level.

tribute of Thai I had a substantially higher MIP at +3.1¢ per pound, while the color of this variety added 1.7¢ per pound to its value. The remaining characteristic, stickiness, added 0.6¢ per pound to the participants' evaluation of Thai I.

The Thai II variety apparently lacked the flavor of Thai I, as shown in the MIP of −2.0¢ per pound. However, as evidenced by their positive MIPs, all other attributes were desirable to the households surveyed. The most desirable attribute of this variety appeared to be its texture, with a calculated MIP of +1.2¢ per pound.

Taken together with MIP, change in marginal implicit price gives an indication of the relationship of each of the characteristics to the relative extreme identified by the estimated equations. For illustration, characteristics for which the main effects (no cross-terms) were statistically different from zero are discussed. Six characteristics had inverted U-shaped curves (Lemont—texture; Jasmine 85—aroma and moisture; and Thai II—aroma, stickiness, and texture). Four had U-shaped curves (Toro II—texture and stickiness, Thai I—flavor, and Thai II—aftertaste).

The inverted U-shaped curves will be discussed first. For Lemont, the inverted U-shape of texture suggests that texture had passed the peak of desirability and was quickly moving toward the point of excessive texture. For Jasmine 85, this indicated that both aroma and moisture desirability were decreasing at an increasing rate, suggesting that for both characteristics, Jasmine 85 was beyond the maximum desired. In terms of moisture, Jasmine 85 was beyond the maximum wetness level desired by study respondents. Interpretation of the aroma characteristics was not so straightforward. The aroma of Jasmine 85 may be excessive or it may be of the wrong type, as suggested in focus group research (Goodwin et al.). Aroma of the Thai II rice may have an interpretation similar to the Jasmine 85 aroma—either the wrong aroma or too much of the right one. Strong aromas often are not desirable in certain foods. Stickiness and texture of Thai II may have an interpretation similar to that for Jasmine 85 moisture.

U-shaped curves for texture and stickiness for Toro II suggest there may be an undesirable band of both texture and stickiness. That is, respondents indicated a preference for either soft or firm rice and either separate or sticky rice, but not for rice of intermediate texture or stickiness. No explanation is posited

Table 5. Survey and Estimation Mean Rice Variety Prices ($/lb. and $/25-lb. bag)

	Variety				
Price	Lemont	Jasmine 85	Toro II	Thai I	Thai II
Survey ($/lb.)	0.3094	0.2987	0.3084	0.3254	0.3167
Estimated ($/lb.)	0.3216	0.2896	0.2957	0.3186	0.3101
Survey ($/25 lbs.)	7.74	7.47	7.71	8.14	7.92
Estimated ($/25 lbs.)	8.04	7.24	7.39	7.96	7.75

for the flavor of the Thai I rice or the aftertaste of the Thai II rice.

Prices for each variety were estimated at the means and are compared with mean prices calculated from survey respondents in table 5. Estimated prices were below the survey prices for all but the Lemont variety, and ranged from 2.1% to 3.8% off the survey prices. Price per 25 pounds, the typical package size of rice purchased by Asian Americans, ranged from $7.47 to $8.14 for survey results. These prices are somewhat below the range for retail prices of Thai imported rice, which sells for $7.99 to $8.99 per 25 pounds. Proximity of the estimated price to both the survey price and the range of retail price for Thai imported rice adds robustness to the model estimates and lends further credibility to the appropriateness of the CGCM approach in estimating rice price based upon product characteristics' desirability.

Implications for the Market

Conventional thinking in today's rice market maintains that the superior color and aroma possessed by Thai Jasmine have been the primary quality attributes contributing to its dominance in the imported rice market. Domestic aromatics (Jasmine 85 in this study) have not been able to penetrate this Asian-American market, presumably for the same reason. However, results of this study suggest that, while Jasmine 85 may lack the aroma of preferred Thai aromatic imports, the texture and aftertaste of Jasmine 85 are considered desirable by Asian Americans, as reflected by the MIPs of +1.1¢ and +1.3¢ per pound, respectively. One may speculate, then, that perhaps color and aroma are "tags" to identify rice with certain textural characteristics desired by the market.

The two domestic non-aromatic rices (Lemont and Toro II) varied in magnitudes and signs of calculated marginal implicit prices. Toro II seems to have an advantage over Lemont in the characteristics of aroma, texture, and moisture, based upon calculated MIPs. Similarly, it could be that enhancing the stickiness and flavor of Toro II, or the aroma and texture of Lemont, could result in varieties competitive with Thai imports in the marketplace.

As previously noted, some varieties are not currently marketed in the U.S. This is also the case with observed behavior in the marketing of Thai Jasmine imports. Thai rice is typically blended before marketing in order to provide various characteristics at different levels of intensity, and therefore at different prices. This is accomplished by mixing old crop and new crop Thai rice, or by blending non-aromatic long-grain varieties with Thai Jasmine. If a suitable U.S. variety could be identified or developed and marketed as a pure variety, the consistent quality characteristics provided might position the U.S. rice to favorably compete with the Thai imports.

With regard to the price information utilized to estimate implicit prices for the various rice attributes, it is useful to consider the contingent valuation approach that was used. Such an approach allows estimation of specific characteristics of a good in a specific market even if real market price information is absent. This can enable product development specialists to estimate the effects of changing an existing product or developing a new product before the improved product is actually created.

In addition, this type of approach to generating price information could enable geneticists and others in plant or animal development to target certain varieties or genotypes for commercialization based upon their supposed marketability and/or profitability. Application of this information could therefore lead to more effective utilization of increasingly limited resources for development of experimental plant and animal lines.

The limitation of this price development approach is that it is based on what individuals say they would do, and not on observed behavior. While this technique in no way would replace traditional methods of product test market analysis, it appears to be the best approach in identifying "price" information which is not yet available.

References

Chiou, G.T., D.T. Chen, and O. Capps, Jr. "A Structural Investigation of Biotechnological Impacts on Cotton Quality and Returns." *Amer. J. Agr. Econ.* 75(May 1993):467–78.

Eastwood, D.B., J.R. Brooker, and D.E. Terry. "Household Nutrient Demand: Uses of Characteristics Theory and a Common Attributes Model." *S. J. Agr. Econ.* 18,2(December 1986): 235–46.

Goodwin, H.L., Jr., R.B. Holcomb, and M.E. Rister. "A Study of Asian-American Rice Demand." Work. paper, Dept. of Agr. Econ., Texas A&M University, June 1995.

Goodwin, H.L., Jr., M.E. Rister, R.E. Branson, J.W. Stansel, B.D. Webb, J.B. Ward, and K. Kunz. "Market Potential for Domestic Rice Varieties Among Asian Americans." Texas Agricultural Market Research Rep. No. CPM 1-92T, Texas A&M University, November 1992.

Hoerl, A.E., and R.W. Kennard. "Ridge Regression: Biased Estimation for Non-Orthogonal Problems." *Technometrics* 12(February 1970): 55–67.

Jordan, J.L., R.L. Shewfelt, S.E. Prussia, and W.C. Hurst. "Estimated Implicit Marginal Prices of Quality Characteristics of Tomatoes." *S. J. Agr. Econ.* 17,2(December 1985):139–46.

Kmenta, J. *Elements of Econometrics,* 2nd ed. New York: Macmillan Publishing Co., Inc., 1986.

Ladd, G.W., and V. Suvannunt. "A Model of Consumer Goods Characteristics." *Amer. J. Agr. Econ.* 58(August 1976):504–10.

Putnam, J.J., and J.E. Allshore. *1968–1990 Food Consumption, Prices, and Expenditures.* Statis. Bull. No. 825, USDA/Economic Research Service, Washington DC, May 1991.

Rice Foundation. "U.S. Rice Industry Focus on Research 1992." Conference report, Little Rock AR, 9–10 April 1992.

Stansel, J.W. Resident Director, Texas Agricultural Research Extension at Beaumont. Personal communication, July 1993.

Tong, A. Research Scientist, USDA/Human Nutrition Information Service (HNIS), Washington DC. Personal communication, August 1992.

Unnevehr, L.J. "Consumer Demand for Rice Grain Quality and Returns to Research for Quality Improvement in Southeast Asia." *Amer. J. Agr. Econ.* 68(1986):634–41.

USA Rice Council. "Selected Asian-American Ethnic Groups' Preferences for Various Characteristics and Varieties of Rice: A Preliminary Report." Unpublished report, Houston TX, Spring 1989.

U.S. Department of Commerce, Bureau of the Census. *1990 Census of the Population: General Population Characteristics, U.S. Summary.* Washington DC: Government Printing Office, 1993.

Wailes, E.J., and J. Livezey. "U.S. Rice Imports and Domestic Use." In *Rice Situation and Outlook Report,* pp. 13–17. Rep. No. RS-62, USDA/Economic Research Service, Washington DC, October 1991.

Wildenthal, M.T. "Opportunities for Enhancing the Texas Food Processing Industry." Unpublished Ph.D. dissertation, Dept. of Agr. Econ., Texas A&M University, August 1992.