South Korean Millers' Preferences for the Quality Characteristics of Hard White Wheat that is Used in Producing All-purpose Flour

Jaehong Park and Shida Henneberry

Oklahoma State University

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Orlando, FL, February 6-9, 2010

South Korean Millers' Preferences for the Quality Characteristics of Hard White Wheat that is Used in Producing All-purpose Flour

JaeHong Park
Graduate Research Assistant
Dept of Ag Econ, Oklahoma State University

Shida Henneberry
Professor
Dept of Ag Econ, Oklahoma State University

Using the choice-based conjoint analysis and self explicated approach, I elicited South Korean millers' preference and willingness to pay for the quality characteristics of hard white wheat that is used in producing all-purpose flour. In specified seven attributes, test weight, moisture, and price significantly affect to South Korean millers' utility but protein contents, ash, dockage, and falling number does not. South Korean millers are more willing to pay to change the quality characteristics related to the milling yields and profitability, such as test weight, moisture and dockage. But their willingness-to-pay for protein content is not as big as common expectation. Along with the research of Srinivasan (1997), we found that the self-explicated approach yields a slightly (but not statistically significantly) higher predictive validity than does the choice-based conjoint analysis. The results of this study provide not only guideline of quality standards of hard white wheat, but also focus point that U.S. producers have to intensify among quality characteristics of hard white wheat to create demand in South Korean market.

Key Words: Hard White Wheat, South Korean wheat market, Choice-based conjoint analysis, Self-explicated approach, Conditional logit model, Willingness-to-pay.

Hard white (HW) is the newest class of wheat to be grown in the United States. This wheat is closely related to red wheats except for the color genes and has a milder, sweeter flavor, equal fiber, and similar milling and baking qualities. Hard white wheat is used in yeast breads, hard rolls, tortillas, and oriental noodles. This is used in domestic markets and is exported abroad. Hard white wheat is primarily grown in the states of California, Kansas, Colorado, Idaho, Oklahoma, Nebraska, Washington, and Montana. Other states such as North Dakota, South

Dakota, Wyoming, and Oregon also have limited production of HW wheat (Extension Fact Sheet at the Ohio State University).

In South Korea, hard white wheat is mainly used to produce all-purpose flour which is the principal product of South Korean milling companies. All-purpose flour is principally used to make various styles of noodles, such as instant fried noodles, dried noodles, fresh noodles, precooked noodles and frozen noodles. To produce all-purpose flour, South Korean millers use Hard Red Winter (HRW), Western White (WW), Australian Standard White (ASW), Australian Hard (AH). Therefore, hard white wheat producers in U.S. cannot avoid competing with these classes of wheat in order to create demands for hard white wheat in the South Korean market. Considering this situation, this study will give some implications for the U.S. wheat producers, Marketers and policy makers.

There are two objectives of this study. First, we will elicit the preference and willingness-to-pay (US$/MT) of the millers in South Korea for the quality characteristics of hard white wheat that is used in producing all-purpose flour by two methods (choice-based conjoint analysis and self-explicated approach). Second, we will compare the predictive validity of these two methods.

To our knowledge, only two previous studies attempted to measure millers' preference for quality characteristics of wheat. Gallardo et al (2007) investigate Mexican millers' preferences for wheat quality attributes as well as consistency of Hard Red Winter Wheat by using two methods (mean-variance model and negative-exponential expected utility model). There are three find of this study. First, Mexican millers are willing to pay premiums for increases in quality factors such as test weight, protein content, falling number, and dough strength/extensibility. Second, Mexican millers are not particularly sensitive to changes in the variability of wheat quality characteristics. Third, the mean-variance model provides higher external validity than the negative-exponential expected utility model. Kim et al (2000) evaluates the preferences of Japanese millers for the various characteristics of wheat and flour that are used in noodle making in Japan. They found several followed things. Japanese millers prefer wheat with test weight of minimum 80, dockage below 0.4 percent and falling number above 250. Preferences for protein, ash and color were specific for different wheat classes and for use in different noodle flour. Millers also display a preference for amylograph at minimum of 400 BU for noodle flour. For hard wheat millers preferred wheat of U.S. and Canadian origin, but for semi-hard and medium wheat, they preferred Australian origin wheat.

These two studies collected data by using conjoint survey. And they use Multinomial Logit model (MNL) to estimate millers' utility for wheat quality characteristics. However, we used Conditional Logit model (CL) to estimate random utility function. The information we gathered from the choice-based conjoint survey was very different from what we can see in the multinomial logit model, where the explanatory variables different from individual to individual and do not change across options. We can call this feature of information as individual specific. But the quality characteristics, variables we dealt with, vary from option to option. We can call this feature of information as alternative specific. The alternative specific data can be estimated using Conditional Logit model of MaFadden (1973).

Hard White Wheat Production and Analyses for South Korean Wheat Market

According to National Agricultural Statistics Service (NASS), total Hard White wheat production in 2008 was about 790,000 metric tons (MT). It is slightly more than 2007, which was 735,000 MT. However, as table 1 show, it is only 1.2 percent of the U.S. total wheat production. This amount is too small to export to other countries consistently.

For South Korean wheat market, we analyzed the current trend of South Korean wheat and wheat flour production, wheat imports and tariffs, the market share of main sources (U.S., Australia, and Canada), the usage of wheat by class, and the proportion of wheat flour use in various wheat-based products.

Total domestic wheat production in South Korea was around ten thousand tons whereas import quantity was 2.28 million tons in 2008. Domestic wheat production proportioned about 0.5 percent of total wheat use. Thus, most of the wheat consumption in South Korea depends on imports (Korea Ministry for Food, Agriculture, Forestry and Fisheries, Agricultural Production Statistics).

Generally, South Korean millers produce three types of flour: all-purpose flour, bread flour, and cake flour to meet the demands of various food manufacturers and consumers. As table 2 shows, total wheat flour production consisted of 68 percent of all-purpose flour, 18 percent of bread flour, and 13 percent of cake flour, respectively (Korea Flour Mills Industrial Association, present status of South Korea Flour Milling Industry).

Wheat import in South Korea has stably persisted at 2.1 ~ 2.5 million tons during the last decade. The current tariff on the wheat for milling is 1.8 percent and the wheat for feedstuff is none in South Korea. As a result of U.S. and Korea FTA, the tariff on milling wheat would be eliminated.

As figure 1 shows, the market share of Australian wheat in South Korea had increased from 34 percent to 45 percent during 1998~2006. But currently, it has drastically decreased to 29 percent. As shown in table 3, the production of Australian wheat decreased due to severe draught in 2006 and 2007. For 2006-07 and 2007-08 crop year, production of Australian wheat was below 53 percent and 39 percent from the previous four year average (Australian Crop Report 2007). The market share of the U.S. wheat had decreased from 60 percent to 50 percent during the 1998~2006. But currently, it has increased back to 65 percent. It was mainly caused from sharply reduced Australian wheat production. The market share of Canadian wheat was steady at 4~6 percent during the last decade.

As table 4 shows, South Korea imports wheat from the U.S., Australia, and Canada. The classes of imported U.S. wheat are Dark Northern Spring (DNS), Hard Red Winter (HRW) and Western White (WW)/ Soft White (SW) wheat. In the South Korean market, DNS is used for making white bread or blended with WW/SW for making instant fried noodles. HRW is blended with WW/SW to produce all-purpose flour. WW (protein 8.5 percent) is also used for making snacks. Currently, the imports of the U.S. wheat have increased in South Korean market, especially HRW increased a lot. The classes of imported Australian wheat are Australian Standard White (ASW), Australian Hard (AH) and Australian Soft (AS). ASW is principally used for making noodles (instant dried and fresh noodles). AH is also used for making noodles. AS with 8.2 percent protein content is used for making snacks. Only one class of Canadian wheat, Canadian Western Red Spring (CWRS), is imported into South Korea. CWRS is mainly used for making bread (Choi, 2003).

As table 5 shows, South Korea mainly used wheat flour for making noodles (47 percent), breads (18 percent) and confectioneries (11 percent) in 2008. Since 1995 the noodle share of total wheat flour consumption has declined, but the bread's share has increased.

Survey Design and method

Based on previous literature and the consultation with experts in wheat milling industry, we decided on quality attributes and attribute levels to construct the survey questionnaire. The selected quality attributes are protein, test weight, moisture, ash, dockage, and falling number. There might be some correlation between these attributes. However, for this study's purposes and ease of estimation, we assume no correlation between attributes. Here, we provide brief description of each quality attributes that we chose for this study to assist readers' comprehension. Protein content is the single most important determinant used for categorization of wheat classes, quality and price. Protein quality depends on the genetics of wheat varieties and growing conditions. Test weight is an important quality factor since it measures the density of wheat kernels, which directly correlates with flour yield. One would expect a positive implicit value for test weight. Moisture content indicates the proportion of dry matter in the wheat kernel. A high moisture level might lead to infestation and damage of wheat during storage. Hence, one would expect a negative effect of moisture on price. Ash is the inorganic residue after incinerating a specific amount of wheat. It yields flour of an inferior milling quality. Hence, one would expect a negative effect of ash content on price. Dockage level measures the content of foreign materials in wheat grains. It should be negatively correlated with flour yield and should have a negative implicit value. Falling number is an index of amylase activity. As the index increases, higher amylo-viscosity flour can be produced. In turn, the higher amylo-viscosity flour will give a desirable springy and smooth texture to final noodle products. As table 6 shows, we selected two attribute levels for the choice-based conjoint survey and four or five attribute levels for the self-explicated approach to see detailed variation of partworths at each attributes' level. Because South Korean millers use wheat has 10 to 12 percent of protein content to produce all purpose flour, we decided protein level between 10 to 12 percent for our survey. Additionally, South Korean millers use wheat has about 14 percent of protein content to produce bread flour and use wheat has lesser than 10 percent of protein content to produce cake flour.

In choice-based conjoint survey for conditional logit model, each wheat option was described by the seven attributes and two levels. This means that there are 2^7= 128 possible wheat profiles can be created. This, of course, can be too many combinations for any survey respondent to reasonably evaluate. So, main effects "fractional factorial design" was used to select 30 profiles. Each respondent answered fifteen questions for the conjoint survey. Respondents chose from two products alternatives (Option A and Option B). Alternatively, respondents could choose option C, a non-choice option. Option A and option B provide different profiles of the product, based on the specified attributes and levels, while option C, the non-choice option, provides a "base" option that sets the origin of the utility scale. The base option acts as a constant subtracted from the utilities of the other options (Louviere, 1992).

Both conjoint and self-explicated survey was conducted among the representatives of wheat milling companies in South Korea during May and June, 2009 by direct interview. Korea Flour Mills Industrial Association (KOFMIA) provided a list and the information about the South Korea Flour milling industry. With the assistance of KOFMIA, we surveyed ten representatives from six companies. Because of different opinions between purchasing and quality control manger, we surveyed the same number of representatives from each department to reduce the measurement error. Usually, purchasing managers put a premium on price attribute, whereas quality control managers put a premium on quality attributes such as protein, ash, falling number. The six companies represent 96 percent of total wheat imports into South Korea. Thus, although the sample size is somewhat small in terms of the number of respondents, the respondents account for most of the millers in South Korea. We visited four different cities to do this survey; even though most of the headquarters of South Korean milling companies are located in Seoul, the capital of South Korea, the factories are located in the cities near the harbor, like Incheon, Busan, Mokpo and Asan.

Methodology

Choice-Based Conjoint Analysis

Because the choice questions can be analyzed using the random utility framework of McFadden, we modeled discrete choices among product alternatives in a random utility framework. In random utility framework, the systemic portion of the utility function depends on the attributes of the choice option. In addition to this systematic portion, the utility function contains a stochastic error term representing the fact that the analyst cannot observe people's preferences with certainty. It is assumed that the consumer chooses the option that generates the highest utility given in the available choice options and constrains. More formally, a random utility function may be defined by a deterministic (V_{im}) and a stochastic (ε_{im}) component:

(1) $U_{im} = V_{im} + \varepsilon_{im}$

U_{im} is the *i*th miller's utility of choosing option *m*. V_{im} is the systematic portion of the utility function determined by wheat quality attributes in option *m*, and ε_{im} is a stochastic element. In this study, the millers' utility function for wheat option *m* is a function of protein, test weight, moisture, ash, dockage, falling number, and price:

(2) $V_{im} = \alpha_m + \beta_1 \text{ (protein)}_m + \beta_2 \text{ (test weight)}_m + \beta_3 \text{ (moisture)}_m + \beta_4 \text{ (ash)}_m + \beta_5 \text{ (dockage)}_m + \beta_6 \text{ (falling number)}_m + \beta_7 \text{ (price)}_m$

Where α_m is an alternative specific constant (intercept term), and β_k represents marginal utilities of each of the attributes. The probability that a consumer chooses alternative *m* from a choice set with *M* possible choice options is

(3) Prob $\{V_{im} + \varepsilon_{im} \geq V_{in} + \varepsilon_{in} \quad \text{for all } n \neq m\}$

We constructed a model for the probability that individual *i* choose alternative *m.* In this research, $i = 1, 2, \ldots, 10$ and $m = 1, 2$, and 3, thus the conditional logit model specifies these probabilities as

(4) $p_{im} = P$ [individual *i* choose alternative *m*]

$$= \frac{\exp(\alpha_m + \sum_{k=1}^{7} \beta_k \text{attribute level}_{im})}{\exp(\alpha_1 + \sum_{k=1}^{7} \beta_k \text{attribute level}_{i1}) + \exp(\alpha_2 + \sum_{k=1}^{7} \beta_k \text{attribute level}_{i2}) + \exp(\alpha_3 + \sum_{k=1}^{7} \beta_k \text{attribute level}_{i3})}$$

Unlike the probabilities for the multinomial logit model, there is only *k* parameter (β_k) relating the effect of wheat quality attributes to the choice of probability p_{im}. We also included alternative specific constants. These cannot all be estimated, and one must be set to zero. We set $\alpha_3 = 0$.

Self-Explicated Approach

We now outline the two steps in the self-explicated approach: data collection, calculation of self-explicated partworths.

Data collection. The data collection proceeds in the following two steps:

1. From the specified wheat quality attribute levels, determine the most-preferred and least-preferred levels, and set their desirability ratings at ten and one, respectively. Then, obtain the desirability ratings (from one to ten) for other attribute levels.

2. determine respondents' relative importance of the specified attributes so that their sum across all the attributes equals 100.

Calculation of self-explicated partworths. Let I_{ij} denote the importance weight given by respondent i (i = 1, 2, …, 10) for attribute j (j = 1, 2, …, 7). (That is, $\sum_{j=1}^{7} I_{ij} = 100$). Then obtain self-explicated partworths for attribute levels by multiplying the importance ratings with the desirability ratings:

(5) $P_{ijk} = I_{ij} (D_{ijk}/10)$,

Where P_{ijk} = respondent i's self-explicated partworth for attribute j's kth level

Iij = responcent i's importance for attribute j

D_{ijk} = respondent i's desirability rating (from one to ten) for attributes j's kth level

After calculating parthworths, normalize them so that their sum over levels within each attribute equals 0, as the partworths within an attribute are determined only up to an additive constant. Consequently, U_i, the predicted preference of miller i, can be computed sum of the self-explicated partworth for attribute j's kth level.

(6) $U_i = \sum_{j=1}^{7} P_{ijk}$

Results

Results from Choice-Based Conjoint Analysis: Conditional Logit Model Estimates

We estimate the conditional logit model with choice-based conjoint survey data. The estimates are shown in table 7. We see that the signs of the coefficient of moisture, ash, dockage, and price are negative, and those of protein, test weight, and falling number are positive as we expected. This means that a rise in the moisture, ash, dockage, and price of an individual option will reduce the probability of its purchase, and the rise in the protein, test weight, and falling number of an individual option will increase the probability of its purchase. We also see that the parameter estimates of test weight, moisture, and price are statistically significant at five percent level. This means that there is enough evidence that this parameter estimates is different from zero. Notable fact in our estimates is that the parameter estimate of protein is not statistically significant at five percent level. This means that there is not enough evidence that the parameter estimate of protein is different from zero. This result is inconsistent with our expectation because it is common sense that South Korean millers consider protein and price as a main factor when they decide to buy wheat. Thus, from our estimates, we can conclude that the protein contents from ten to twelve percent do not significantly affect South Korean millers when they decide to purchase wheat that is used in producing all-purpose flour.

Marginal willingness-to-pay is the maximum monetary amount that a miller would pay to increase (or reduce) a one-unit of the quality characteristic. This statistic is easily calculated by dividing the quality characteristic coefficient by the price coefficient (multiplied by negative one). Although estimates of marginal willingness-to-pay are of interest, farmers, millers and marketers are more interested in estimating the value of moving from "low" to a "high" level of each attribute over the range that is typically observed in reality. Thus, table 8 reports willingness-to-pay for attributes from lower level to higher level employed in the conjoint survey. These willingness-to-pay estimates are obtained by multiplying the marginal willingness-to-pay by the difference between the high and low quality level. Results indicate that South Korean millers are willing to pay $47/MT, $10.96/MT, and $7.66/MT to increase the test weight from 75 to 85 kg/hl, the protein content from 10 to 12 percent, and the falling number from 340 to 420 seconds, respectively. Also they are willing to pay $27.55/MT, $13.87/MT, and $5.98/MT to reduce the moisture from 12 to 8 percent, the dockage from 0.5 to 0.2 percent, and the ash from 1.8 to 1.4 percent, respectively. These results also indicate that South Korean millers are more willing to pay to change the quality characteristics related to the milling yields and profitability, such as test weight, moisture and dockage. Low test weight tells millers that they will have a lower production of usable flour. Wheat that is plump and has a high test weight is very valuable to the millers because it provides a high flour extraction (Northern Crops Institute, Understanding Wheat Quality Tests).

Self-Explicated Approach

As shown in Figure 2, we can see detailed variation of partworths at each attribute's level. Greater than zero partworth indicates that it exceeds average partworth because partworths are normalized so that their means are zero. In the following description, a attribute level is preferred means that it has excess partworth compared to attribute level which has zero partworth. And each partworth was calculated by averaging individual's partworth. South Korean millers prefer from 10.5 to 11.5 percent of protein content while 10.5 percent is most preferred among our specified levels to produce all-purpose flour. A remarkable result is that 12 percent of high protein content is not preferred by South Korean millers. South Korean millers mainly produce all-purpose flour that is used in making noodle.

The wheat has high protein contents should be mixed with low protein wheat when they produce this kind of flour. This mixing procedure takes an extra cost. Test weight from 80 to 85 kg/hl is preferred among our specified levels to produce all-purpose flour. As expected, higher test weight is more preferred. Moisture from eight to ten percent is preferred among our specified levels to produce all-purpose flour while nine percent is most preferred. South Korean millers regard nine percent of moisture as a standard level to produce all-purpose flour. Millers add water to adjust wheat moisture to a standard level before milling. Lower wheat moisture allows more water to be added, increasing the weight of grain to be milled (U.S. Wheat Associates, Crop Quality Report 2008). Ash content from 1.4 to 1.5 percent is preferred among our specified levels to produce all-purpose flour by South Korean millers. As expected, lower ash content is more preferred. Ash in flour can impart a darker color to finished products (U.S. Wheat Associates, Crop Quality Report 2008). Noodle products require particularly white flour. And about fifty percent of wheat flour is used to make various noodle products in South Korea. Thus South Korean millers inevitably prefer the wheat has low ash content. Dockage level from 0.2 to 0.3 percent is preferred among our specified levels to produce all-purpose flour. As expected, lower dockage level is more preferred. Falling number from 380 to 420 seconds is preferred among our specified levels to produce all-purpose flour. As expected, higher falling number is more preferred.

Willingness-to-Pay also can be derived from Self-Explicated Approach using the slope between attribute level and partworth. Table 9 reports willingness-to-pay for attributes from the lowest level to the highest level employed in the self-explicated approach. Results indicate that South Korean millers are willing to pay $8.34/MT, $6/MT, $0.98/MT to increase falling number from 340 to 420 seconds, test weight from 75 to 85 kg/hl, and protein content from 10 to 12 percent, respectively. Also they are willing to pay $6.39/MT, $6/MT, and $3.99/MT to reduce ash from 1.8 to 1.4 percent, dockage from 0.5 to 0.2 percent, and moisture from 12 to 8 percent, respectively. Remarkable fact in this result is that willingness-to-Pay for enhancing protein content from 10 to 12 percent is not as big as it can be expected. This result is consistent with that of choice-based conjoint analysis.

Predictive Validity

Using equation (4) and (6), we predicted which option would be chosen by each miller in Choice-based conjoint analysis and self-explicated approach, respectively. And we compared the prediction with the option that actually was chosen by the miller. As table 10 shows, the predictive validity of the self-explicated approach is slightly higher than that of choice-based conjoint analysis. The Self-explicated approach correctly predicted 89.2 percent of choices, which represented 78.4 percent improvement over the random model. Choice-based conjoint analysis correctly predicted 88.0 percent of choices, which represented 82.0 percent improvement over the random model. The difference of predictive validity between these two methods could be caused from measurement error of choice-based conjoint survey. We suspect that choice-based conjoint survey, even with only seven attributes and 30 profiles, has too many information for respondents to reasonably evaluate. But we failed to reject the null hypothesis that the predictive validities from these two methods are identical. This means that there is not enough evidence that these two predictive validities are different at a 10 percent significant level. This statistical test was based on the nonparametric Wilcoxon Signed-Rank test for a matched pairs experiment [Wackerly, Mendenhall, and Scheaffer 2002, p.716~722].

The result obtained here, which demonstrates the robust validity of the self-explicated approach, is consistent with Srinivasan and Park (1997). They found that the self-explicated approach yields a slightly (but not statistically significantly) higher predictive validity than does the combined approach.

Concluding remarks

Using the choice-based conjoint analysis and self explicated approach, we elicited South Korean millers' preference and willingness to pay for the quality characteristics of hard white wheat that is used in producing all-purpose flour. Using the actual choice data, we also compared predictive validity of these two utility measurement methods. The results of this study provide not only guideline of quality standards of hard white wheat, but also focus point that U.S. producers have to intensify among quality characteristics of hard white wheat to create demand in the South Korean market.

Although choice-based conjoint analysis and self explicated approach have high predictive validity, the willingness-to-pay from these two methods is different. Thus we tested these matched pairs using the nonparametric Wilcoxon Signed-Rank test. But we failed to reject the null hypothesis that the willingness-to-pays from these two methods are identical. This means that there is not enough evidence that these two willingness-to-pays are different at ten percent significant level.

Although the U.S. market share in South Korea was temporarily enhanced on account of reduced Australian wheat production, it is imperative to improve the competitiveness of U.S. wheat for making noodles. For past several years, both the U.S. suppliers and South Korean consumers tried effort to export and import of hard white wheat, but there was not significant effect of this tries. Through intensive breeding efforts, the U.S. has developed some promising hard white wheat classes, which could be suitable for making noodles. However, preliminary evaluations by the South Korean millers of U.S. hard white wheat for making noodles has indicated that more improvement of wheat quality is needed to effectively compete with ASW wheat.

Refer to expert opinions in wheat milling industry, the main obstacles that hinder the U.S. suppliers from exporting hard white wheat is inappropriate quality and inconsistent supply and quality. Therefore, we suggest following two things should be carried out, in advance, to enhance market share of the U.S. hard white wheat instead of ASW wheat in South Korean market. First, the production infrastructure should be enlarged to produce more hard white wheat. As shown in previous chapter, hard white wheat production in the U.S. is too small to export to other countries consistently. Second, using the South Korean millers' preferences in the results of this paper, the U.S. suppliers should try effort to meet the guideline for hard white wheat quality characteristics. In addition to upgrading the quality of wheat, maintaining consistent quality is also an important factor for market competitiveness. South Korean millers expect improved consistency in hard white wheat quality, since consistent quality of wheat grains increases milling efficiency and provides consistent quality of wheat flour for end users.

If quality and consistency requirement for making noodle will be met, there is enough demand for hard white wheat in the South Korean market. Because about fifty percent of wheats are used to make noodles in South Korea. Especially, Pacific northwest production area such as California, Idaho, Oregon, and Washington has advantage in exporting hard white wheat to South Korea because transportation cost is lower than other production area in the U.S.

References

Australian Bureau of Agricultural and Resource Economics (ABARE). 2007. *Australian Crop Report*.

Choi, J.H. 2003. "Competitiveness of Major Wheat Exporters in the Korean Market." *Journal of Rural Development* 26:127~148.

Dendy, D.A., and B.J. Dobraszczyk. 2001. *Cereals and Cereal Products: Chemistry and Technology*: Aspen Publication.

Extension Fact Sheet at the Ohio State University. "*Classes and Uses of Wheat*." Available at http://ohioline.osu.edu/agf-fact/0146.html , Accessed May 03 2009.

Gallardo, R.K., J.L. Lusk, R.B. Holcomb, and P. Rayas-Duarte. 2007. "Mexican Millers' Demand for Quality and Consistency in Hard Red Winter Wheat." Unpublished PhD dissertation, Oklahoma State University.

Hill, R.C., W.E. Griffiths, and G.C. Lim. *Priciples of econometrics*: John Wiley & Sons, 2008.

Kim, R.B., J. Unterschultz, and M. Veeman. 2000. "Japanese Miller's preferences for wheat and flour: A stated Preference Analysis." presented at the Western Agricultural Economic Association Annual Meetings.

Korea Flour Mills Industrial Association (KOFMIA). 2009. *The present status of South Korea Flour Milling Industry*. Seoul.

Korea Ministry for Food, Agriculture, Forestry and Fisheries. *Agricultural Production Statistics*. Available at http://www.mifaff.go.kr/USR/WPGE0201/m_119/DTL.jsp, Accessed June 13 2009.

Louviere, J. 1992. "Experimental Choice Analysis: Introduction and Overview." *Journal of Business Research* 24:89~95.

Lusk, J.L., and N. Parker. 2009. "Consumer Preferences for Amount and Type of Fat in Ground Beef." *Journal of Agricultural and Applied Economics* 41 (1): 75~90.

McFadden, D. "Conditional Logit Analysis of Qualitive Choice Behavior." *Frontier in Econometrics*. P. Zarembka, ed. New York: Academic Press, 1973.

Northern Crops Institute. *Understanding Wheat Quality Tests*. Available at http://www.northern-crops.com/technical/fallingnumber.htm, Accessed January 17 2009.

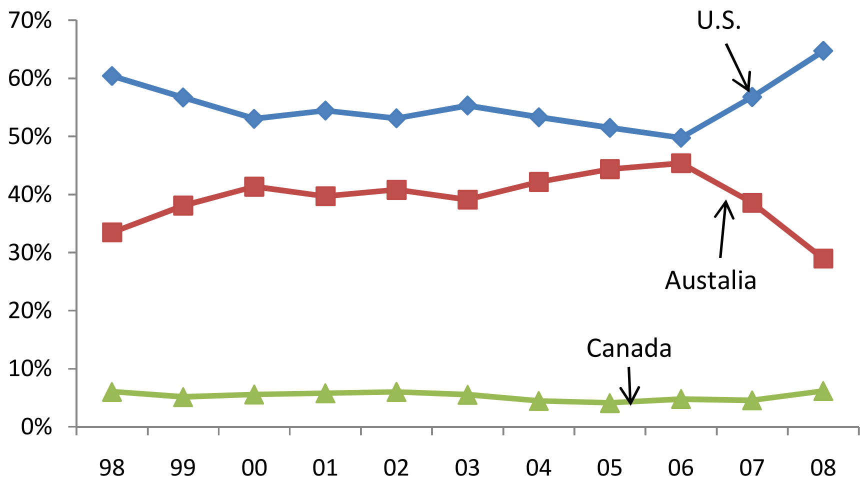
Srinivasan, V., and C.S. Park. 1997. "Surprising Robustness of the Self-Explicated Approach to Customer Preference Structure Measurement." *Journal of Marketing Research* 34:286-91.

U.S. National Agricultural Statistics Service (NASS). *Crop Production*. Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do;jsessionid=7C4CA7E909F615AECC4D376FDF802D14?documentID=1046, Accessed August 27.

U.S. Wheat Associates. 2008. *Crop Quality Report 2008*. Available at http://www.uswheat.org/cropQualityReports, Accessed April 02 2009.

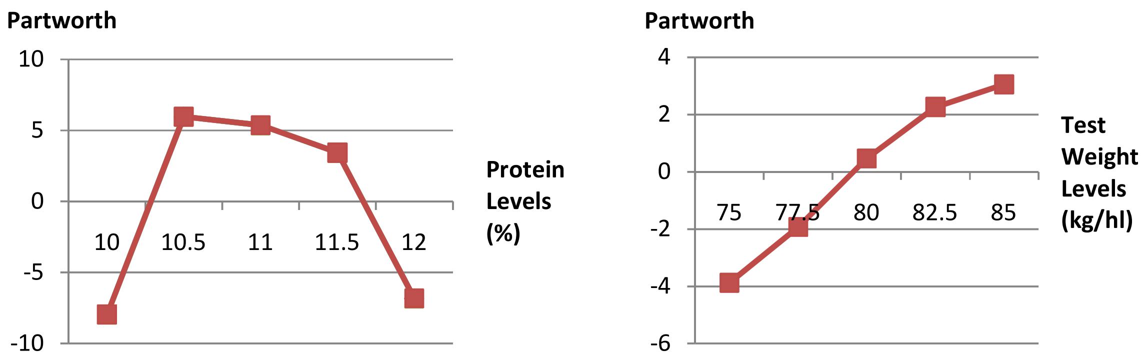
Wackerly, D.D., W. Mendenhall, and R.L. Scheaffer. *Mathematical Statistics with Applications*.: Duxbury, 2002.

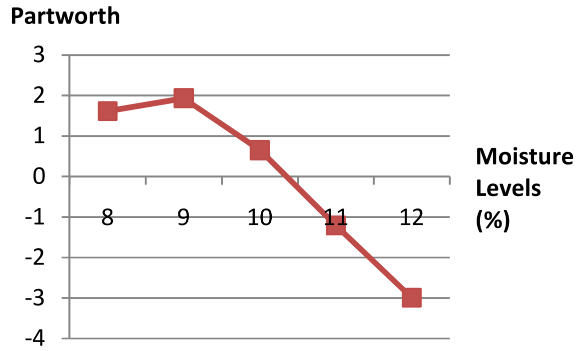
Figure 1 . The Market Shares of Imported Wheat in South Korea

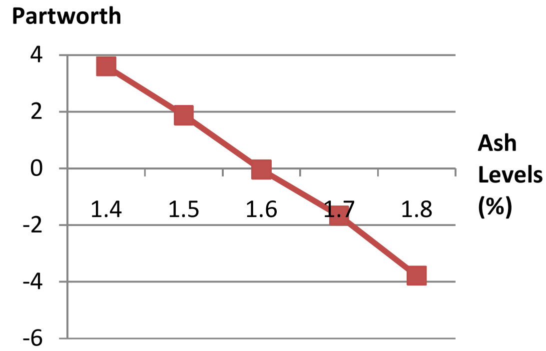


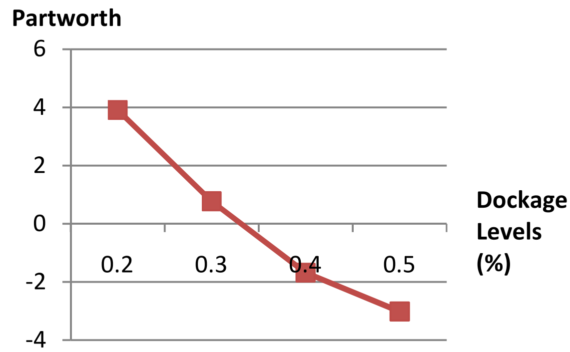
Source: KOFMIA.

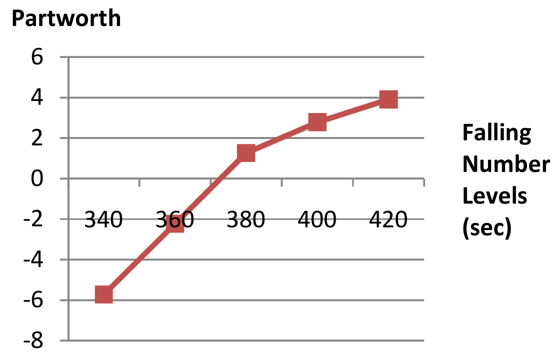
Figure 2. Self-Explicated Partworth for Each Attributes' Level











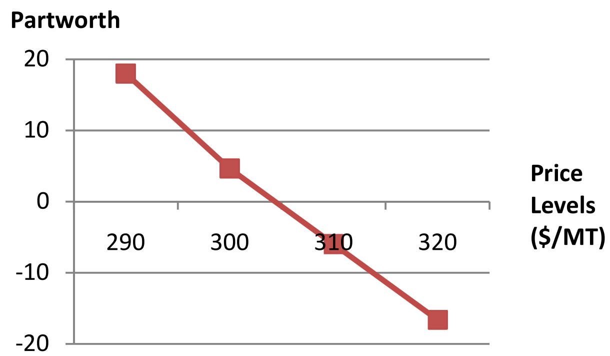


Table 1. The U.S. Wheat Production by Class

Unit: Million MT

	2004	2005	2006	2007	2008
Hard Red Winter	23.30	25.31	18.56	26.17	28.18
Soft Red Winter	10.35	8.41	10.62	9.74	16.70
Hard Red Spring	14.30	12.70	11.77	12.22	13.92
Soft White	6.99	7.33	7.30	5.43	6.13
Hard White	1.10	0.81	0.53	0.74	0.79
Durum	2.45	2.75	1.46	1.96	2.31
Total	58.49	57.31	50.24	56.26	68.03

Unit was converted based on information provided by NASS, Crop Production Report.

Table 2. The proportion of wheat flour production by type in South Korea

Unit: %

	00	01	02	03	04	05	06	07	08
All-purpose	65.9	66.5	64.6	64.2	65.1	64.1	64.7	65.8	68.4
Bread	16.5	17	18	18.3	18	18.3	17.9	17.8	18.2
Cake	15.6	16.5	17.4	17.5	16.9	17.6	17.4	16.4	13.4
total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: KOFMIA

Table 3. Australia Wheat Production

Unit: 1000 ton

Crop year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Production	10,132	26,132	21,905	25,367	9,819	12,695

Source: ABARE (Australian Bureau of Agricultural and Resource Economics).

Table 4. Wheat Import by class and Origin

Unit: Ton

Class	Protein (%)		2006		2007		2008	
	Min	Max	Quantity	Ratio (%)	Quantity	Ratio (%)	Quantity	Ratio (%)
WW/SW			394,859	17.6	462,725	22.4	574,704	25.2
WW/SW		8.5	98,097	4.4	44,613	2.2	38,958	1.7
WW/SW		9.5	39,550	1.8	77,759	3.8	93,242	4.1
WC			455	0.0				
HW							2,620	0.1
HRW	11.5		217,138	9.7	242,224	11.7	385,921	16.9
DNS	14.0		325,492	14.5	312,039	15.1	355,541	15.6
DNS	14.5		34,245	1.5	31,303	1.5	15,747	0.7
SRW			7,121	0.3	5,063	0.2	6,885	0.3
U.S. subtotal			1,116,957	49.8	1,175,726	56.8	1,473,618	64.7
AS			8,700	0.4	2,131	0.1	5,300	0.2
ASW			917,976	40.9	717,263	34.7	593,514	26.1
AH			92,822	4.1	79,793	3.9	61,506	2.7
Australia subtotal			1,019,498	45.4	799,187	38.6	660,320	29.0
2CWRS	13.5		108,119	4.8	94,908	4.6	141,547	6.2
Canada subtotal			108,119	4.8	94,908	4.6	141,547	6.2
Organic							1,844	0.1
Total			2,244,574	100	2,069,641	100	2,277,329	100

Source: KOFMIA.

Table 5. The Proportion of Wheat Flour Use in Various Wheat-Based Products[1]

Unit: %

	Noodles	Breads	Confectionary	Soft Beverage	Soy Sauce	Feedstuff	Others[2]	Total
1990	45.9	12.0	14.5	7.3	3.7	0	16.6	100.0
1995	57.3	12.8	10.3	2.1	3.2	0	14.3	100.0
1998	51.8	14.0	9.4	2.1	3.1	0	19.6	100.0
2000	51.3	13.2	10.8	1.4	2.9	7.7	12.7	100.0
2001	49.6	14.2	10.5	1.5	3.3	7.7	13.2	100.0
2002	50.0	14.7	10.0	1.4	3.5	7.2	13.2	100.0
2003	49.6	14.4	10.4	1.3	3.9	7.1	13.3	100.0
2004	48.2	14.9	10.6	1.3	3.8	6.8	14.4	100.0
2005	47.9	15.3	10.6	1.5	3.9	6.4	14.4	100.0
2006	46.0	15.4	10.8	1.9	3.6	6.4	15.9	100.0
2007	46.4	17.0	10.9	1.5	3.8	5.5	14.9	100.0
2008	46.6	17.6	11.4	1.8	3.9	5.3	13.4	100.0

[1] Shares were recalculated based on information provided by KOFMIA.
[2] Restaurant use, rice cakes, industrial use and other flour products are included.

Table 6. Attributes and attribute Levels in the Conjoint and Self-explicated Survey

Attributes	Levels						
	Conjoint Survey		Self-Explicated Approach				
Protein (%)[a]	10	12	10	10.5	11.0	11.5	12
Test Weight (kg/hl)	75	85	75	77.5	80.0	82.5	85
Moisture (%)	8	12	8	9	10	11	12
Ash (%)	1.4	1.8	1.4	1.5	1.6	1.7	1.8
Dockage (%)	0.2	0.5	0.2	0.3	0.4	0.5	
Falling Number (sec)	340	420	340	360	380	400	420
Price (US$/MT)[b]	290	320	290	300	310	320	

Table 7. Results from Choice-Based Conjoint Suvrvey: Conditional Logit Model Estimates

Attribute		Parameter Estimate
Protein		0.166 (0.123)[a]
Test weight		0.142 (0.025)*[b]
Moisture		-0.209 (0.073)*
Ash		-0.453 (0.704)
Dockage		-1.401 (0.888)
Falling number		0.003 (0.003)
Price		-0.030 (0.007)*
Number of Respondents	10	
Number of choices	150	
Log likelihood	-109.462	
McFadden's LRI	0.336	

[a] The Numbers in parentheses are standard errors.

[b] One (*) asterisk represent 0.05 level of statistical significance.

Table 8. South Korean Millers' Willingness-to-Pay for Quality Characteristics of Hard White Wheat: from the Conditional Logit Estimates

Quality Characteristic	Willingness-to-Pay ($/MT)
Protein (%): from 10 to 12	10.96
Test weight (kg/hl): from 75 to 85	47.00
Moisture (%): from 8 to 12	-27.55
Ash (%): from 1.4 to 1.8	-5.98
Dockage (%): from 0.2 to 0.5	-13.87
Falling # (sec): from 340 to 420	7.66

Table 9. South Korean Millers' Willingness-to-Pay for Quality Characteristics of Hard White Wheat: from Self-Explicated Approach

Quality Characteristic	Willingness-to-Pay ($/MT)
Protein (%): from 10 to 12	0.98
Test weight (kg/hl): from 75 to 85	6.00
Moisture (%): from 8 to 12	-3.99
Ash (%): from 1.4 to 1.8	-6.39
Dockage (%): from 0.2 to 0.5	-6.00
Falling # (sec): from 340 to 420	8.34

Table 10. Comparaison of Predictive Validities

Methods	Number of Attributes	Percentage of Actual Choices Correctly Predicted	Percent Improvement over Random Model[a]
Choice-Based Conjoint analysis	7	88.0	82.0
Self-explicated apporach	7	89.2	78.4

[a] 100 × [(percent correctly predicted by the approach − percent correctly predicted by random model)/(100 − percent correctly predicted by random model)]. The random model would be predicted 33.3 percent for choice-based conjoint analysis and 50 percent for self-explicated approach of the choices correctly.