Japanese Millers’ Preferences for Wheat and Flour: A Stated Preference Analysis

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Abstract

Japan imports 6.3 MMT of wheat annually and consumes almost 35 percent of this in the form of noodles. The purpose of this paper is to report on a study that evaluates the preferences of Japanese millers for the various characteristics of wheat and flour that are used in noodle making in Japan. The study used stated preference methodologies (SPM), that were developed and pre-tested through initial interviews with Japanese flour millers. In total, 57 purchase and quality managers for 22 Japanese milling companies were surveyed by means of direct interviews and 41 respondents completed the full SPM survey. Multinomial logit models of millers' preferences were developed and tested and the parameter estimates of these are reported in the paper. This elicited their choices of wheat and flour with alternative combinations of characteristics, at specified levels, for various wheat classes and noodle flours. Data were also collected on stated choices for wheat sourced from different origins. Millers prefer wheat with test weights of minimum 80, dockage below 0.4 percent and falling numbers above 250. Preferences for protein, ash and color were specific for different wheat classes and for use in different noodle flours. 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 results may assist wheat breeders and traders in exporting nations in marketing their products and positioning these in this important and premium wheat market.

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Introduction

Wheat importation by East Asian countries accounts for about 34 percent of world wheat trade. Japan is the second largest wheat importer in East Asia, and has stable imports of 6 MMT of high quality wheat per annum. Approximately 85 percent of the wheat demand is met by imports (JFA, 1999). Japan has rigid administration on wheat importation by the Japan Food Agency (JFA). The JFA has had exclusive rights to control price and quantity of wheat, rice and barley in Japan since 1942.

The JFA sets a specific amount of import quota for three major wheat exporters- the U.S., Australia and Canada on an annual basis. It determines the domestic wheat purchase plan each year in August and September in consultation with the representatives of flour millers and the domestic wheat producers. Once the domestic purchase plan is set, the JFA hold a semi-annual meetings with flour millers, bakers, noodle makers and private grain traders to finalize its wheat import plan. The grain traders, licensed by the JFA, import wheat by class at world prices under the aggregate import quota and tender the wheat to the JFA at their purchase price plus a mark-up reflecting ocean freight, insurance, carrying costs. The JFA then resells the imported wheat to domestic millers at administered resale prices. Hence, preferences of millers and secondary processors are not reflected at the import demand level for wheat imports by grain traders under this system.

However, the flour milling industry in Japan is now facing increasing pressures to deregulate. This arises for various reasons, including over-capacity in the milling industry and concern as to the high levels of cost of subsidies for domestic wheat growers. In addition, changes in trade practices have been adopted to accommodate a less protected international trading environment arising from the 1994 Agreement on Agriculture of the General Agreement of Tariffs and Trade. Consequently, millers in Japan are also interested in documenting preferences within this industry as they position themselves to operate in a less regulated trading environment. The importation of processed wheat flour has increased in recent years and further reduction of tariffs on wheat flour can be expected to result from future WTO negotiations. Reduction in regulation of the JFA on wheat importation may allow the import market to reveal the preferences of millers and end-users more explicitly.

One of the prominent features of wheat demand in Japan is the increasing demand for wheat used in noodle processing. The Japan Food Agency (JFA) has identified the Japanese instant noodle industry as a high growth market, while the bakery and bread industry in Japan are viewed as more of a "zero-sum" market. The Japanese instant noodle industry grew at 1.8 percent and 3.3 percent in 1995 and 1996, respectively, while the total growth rate of Japanese bread production over the last four years has been near zero percent (JFA, 1997). The noodle market is the most important category of use for wheat flour in Japan. Four major types of noodles in Japan are dry noodles, fresh udon noodles, fresh ramen noodles and instant ramen noodles.

The purpose of this study is to evaluate the nature of preferences by Japanese millers on wheat and wheat flour qualities for noodle uses. Such information may assist wheat breeders and traders in exporting nations, especially those wheat exporters, such as Canada, that have played a relatively minor role in supplying wheat to the Asian noodle market. The millers are surveyed vis a direct interview and associated survey questionnaire. The study also evaluates the potential effects of wheat product origin on millers' purchasing decisions. A stated preference methodology (SPM) is used for these purposes.

Research Methodology

To analyze preferences of Japanese millers for wheat and wheat flour qualities for the noodle market, the stated preference survey methodology (SPM) is applied. The SPM, often referred to as experimental or stated choice analysis, is a variant of conjoint analysis and assesses buyer's stated responses to numbers of actual or potential product characteristics. The analytic framework is based on the premise that buyers' perceptions of a selected product, as represented by its various characteristics, including price, strongly influence their decision to purchase a product. The SPM applied in this study is based on buyers' hypothetical choice behavior for wheat and wheat flour purchases. Respondents are asked to simulate discrete choice behavior for wheat and wheat flours with specified attributes (Figure 1). This can allow researchers to assess the potential demand for a new product, based on buyers' perceptions of that product or to estimate the response to a change in an existing product.

The SPM is particularly appealing for this study since actual market choices of buyers for noodle processing wheat classes from some wheat exporters, such as Canada, are not available. The SPM has been applied extensively in empirical work in examining choice of travel, environmental amenities, recreational facilities, and in food marketing studies. Recent examples are provided by Unterschultz et al. (1997); Quagrainie et al. (1998) and Kuperis et al. (1999).

The SPM is based on economic principles. Discrete choices among product alternatives are modeled in a random utility framework using a multinomial logit (MNL) model. With an appropriate definition of the attributes and the attribute levels that enter an individual's indirect utility function this function can be expressed as below, following Ben-Akiva and Lerman (1985), Bastell and Louviere (1991) and Adamowitz et al. (1992).

$$U_{in} = V(X_{in}) + e(X_{in}) \quad (1)$$

where: U_{in} is person n's utility of choosing alternative i; V is the systematic component of utility; e is a random element; X_{in}, is a vector of attribute values for alternative i as viewed by respondent n. Total utility, U_{in} is a sum of observable and unobservable components which can be expressed as V and e, respectively. The systematic component is a function of observable attributes of products or brands of a product and individuals, while the random component relates to variations in choice due to within- and between-individual variance, omitted variables, measurement errors and imperfect information (Ben-Akiva and Lerman, 1985).

The probability of individual n choosing alternative i is equal to the probability that the utility of alternative i is greater than the utilities of all other alternatives in the choice set. This can be written as follows:

$$p_n(i) = \Pr(V_{in} + e_{in} \geq V_{jn} + e_{jn}; \text{for all } j \in C_n) \quad (2)$$

where C_n is the choice set for respondent n.

Assuming that the error terms are independently, identically and Gumbel distributed with a scale parameter $m>0$, the probability of choosing an alternative i is defined as the multinomial logit (MNL) model:

$$p_n(i) = \frac{\exp(mV_{in})}{\sum_j \exp(mV_{jn})} \quad (3)$$

Assuming that V_{in} is linear in parameters, the functional form can be expressed as:

$$V_{in} = b_1 + b_2 x_{in2} + ... + b_k x_{ink} \quad (4)$$

where V_{in} is respondent n's conditional indirect utility function; x_{ink} is the kth attribute value for alternative i as viewed by respondent n and b_1 to b_k are coefficients to be estimated. The functional form expressed in equation (4) is additive and indicates that the factors are independent in their respective effects on consumer utility. Thus, interaction effects are assumed to be negligible; consequently only main effects are assessed. The non-nested MNL model as outlined above was applied to analyze the data collected from the survey questionnaires through direct interviews with millers in Japan.

The Questionnaire and Survey Methodology

A survey applying SPM was developed and applied in this study to collect the necessary data. To construct the survey questionnaire, significant factors and factor levels were determined based on consultation with milling industry representatives. An initial round of interviews with industry members identified key factors and factor levels for each noodle market and each wheat market. Follow-up interviews were scheduled to conduct the final SPM survey questionnaire. An example of a choice question is in Figure 1. A listing of the products and attributes is in Figure 2.

The preliminary survey of millers indicated that six versions of the survey were appropriate for wheat. Three versions of the survey were required for assessment of the noodle flour market. These differences arose since appropriate choice variables and associated choice sets were sufficiently different for different classes of wheat and noodle types. Hence, it was necessary to construct different versions of choice sets in each instance to evaluate the demand for hard wheat, semi-hard wheat, medium wheat, udon flour, dry noodle floor, fresh ramen noodle flour and instant ramen noodle flour. Additionally, in order to evaluate the relevant wheat choices that relate to sourcing from different suppliers, another set of wheat choices was constructed and the model associated with this is referred to as "Trade" in Figure 2.

The first set of choices on wheat included the attributes of price, ash content, falling number and test weight. There are separate sets of questions for hard wheat, semi-hard wheat and medium wheat. The second section on flour contained price, color, ash content and amylograph measures as the specified important attributes. There are separate questions on udon, dry noodle, fresh ramen noodle and instant ramen flour. In the last set of choices, referred to as "Trade", price, protein content, country of origin and dockage level were selected as attributes, based on discussions with millers in the initial interviews. Again, there are separate questions for hard, semi-hard and medium wheat. Each major attribute was specified to have four different levels.

A fractional factorial experiment was designed for each product, resulting in 32 choices for each product. To reduce respondent burden, these questions were blocked into four sets, providing eight questions on each product per questionnaire. Each respondent answered eight questions on each wheat subset related to specific wheat characteristic and country of origin. The questionnaires were pre-tested in initial discussions and interviews with millers who also advised on appropriate attributes and the levels of these.

Respondents chose from two product alternatives based on descriptions of the product in terms of specific levels of attributes (alternative A and alternative B) or could choose alternative C, a non-choice option (Figure 1). Alternative A and alternative B provide different profiles of the product, based on the specified attributes, while alternative C, the non-choice option, provides a "base" alternative that sets the origin of the utility scale. Louviere explains that the base alternative acts as a constant subtracted from the utilities of the other alternatives.

A direct interview method of survey was employed in this study. There are 132 millers in Japan, and their plants are located across Japan in four different islands. The interviewer met 57 mill representatives in eight different cities, and 41 of these answered the full survey questionnaire from January 1999 to July 1999. The interviews were conducted in the Japanese language.

The multinomial logit model of Equation (4) was applied to the data elicited from the survey responses. This model assumes that there is only one level of decision making in the millers' wheat purchase decision process. Dummy variables (-1,+1) are used to effects-code the attribute levels so that the base alternative is exactly equal to the origin. The fourth level of each attribute is omitted during estimation, to avoid singularity, and calculated afterward, using the effect-coding constraint that all four attributes must sum to zero. The non-linear logit procedure of the statistical program LIMDEP 7.0 is used for estimation of the MNL model of Equation 4.

The Results and Discussion

Empirical results of the estimated models based on SPM are given in Tables 1 to 3. The coefficient estimates denote the relative effects of attributes on a miller's utility and on the probability of a product being purchased. The estimated coefficients on prices (Table 1) had expected signs and are statistically significant, indicating that buyers prefer lower prices. Ash content is a critical factor used by millers in grading wheat and wheat flour. Ash is composed of inorganic material that yields flour of an inferior milling quality, hence millers prefer ash content at minimum level (Stanmore, 1994). For Hard wheat, ash content at or below 1.60 percent was preferred, while for semi-hard and medium wheat classes; ash content at 1.45 and 1.55 percent or below was preferred, respectively.

Falling number is an index of amylase activity (how active an enzyme is in breaking down carbohydrates). 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. For hard wheat and medium wheat classes, the millers specified a preference for falling number at 380. For semi-hard wheat, they preferred the falling number at 337. Test weight is an important quality factor since it measures the density of wheat kernels, which directly correlates with flour yield. For this factor, 80 was found to be the minimum acceptance level for all three wheat classes.

Protein content is the single most important determinant used for categorization of wheat classes, quality and price. For noodle processing hard wheat, millers preferred 12.8 percent protein, and for semi-hard wheat, a minimum of 10.7 percent protein is preferred. For the soft wheat class, millers prefer a minimum of 9.5

percent protein. Dockage level is another important quality factor which is specified in the terms of the trade contract. It measures the content of foreign materials in wheat grains and indicates purity of wheat grains. Hence, this attribute affects wheat-trading prices. For all three wheat classes, millers prefer dockage levels to be below 0.4 percent.

In evaluating the quality of wheat flour, the color of the flour plays a critical role since this influences the color of noodles. For Udon and dry noodle flour, the L value of flour color, which measures whiteness of flour, is preferred to be 93, and for fresh Ramen flour, 90 is a preferred L value. Millers preferred 92 for instant Ramen flour. The preferred ash content in wheat flour (Table 3) was lower than the preferred ash content for wheat (Table 2). For dry noodle flour, millers strongly rejected ash content above 0.48 percent. They also rejected ash content above 0.50 percent for instant Ramen flour. Millers preferred a minimum of 0.35 percent for Udon and fresh Ramen flour, respectively. Amylgraph numbers measure the elasticity and texture of wheat flour. Amylograph numbers below 400 have a negative impact on millers' choice decisions for all four types of noodle flour.

The effect of the country of origin on millers' utility of imported wheat was estimated in the Trade model version and these estimates are presented in Table 2. The log likelihood ratio statistic indicates that the four attributes examined in this model are jointly important in affecting millers' utility for wheat purchase. The Pseudo R squared value of 0.29 indicates a reasonable fit for this model. For semi-hard wheat and medium wheat classes, wheat of Australian origin is most preferred by Japanese millers. For the hard wheat category, wheat of U.S. origin is most preferred by the millers. Domestic origin has significant positive effect on Japanese millers' preference for the medium wheat category, while Canadian origin has significant positive effect on the millers' choice decision in the hard wheat category.

Conclusions

The study used stated preference methods (SPM) to evaluate millers' attitudes to price, country of origin and other significant quality factors of wheat and wheat flour for noodle manufacture in Japan. Japanese millers are sensitive to price factors for all classes of wheat and wheat flour. Millers prefer U.S. and Canadian origin for hard wheat class, and Australian origin for semi-hard and medium wheat. Thus there is a distinct preference of origin by millers for each wheat class. The SPM is useful in measuring the relative importance of wheat and wheat flour quality and the explicit levels of each of these factors that are preferred by Japanese millers.

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Figures and Tables

Figure 1. Example of stated preference method question

Segment 3: Trade, Medium wheat

Assume that the following alternatives are the only ones on your next order for medium wheat. Would you choose A or B or would you choose neither?

Product Attribute	**Alternative A**	**Alternative B**	**Alternative C**
Price	5% less than previous price paid	Same price as previous price paid	Neither alternative A nor B
Protein level	10.8%	11.5%	
Country of origin	Canada	Australia	
Dockage	0.4	0.6	
I would choose			

Figure 2. Factors/descriptions of product types specified for the SPM choice experiment

Product types in each section

Wheat	Flour	Trade
Hard wheat	Udon flour	Hard wheat
Semi-hard wheat	Dry noodle flour	Semi-hard wheat
Medium wheat	Instant ramen flour	Medium wheat
	Fresh ramen flour	

Quality attributes in each section

Wheat	**Flour**	**Trade**
Price	Price	Price
Ash content	Color	Protein content
Falling number	Ash content	Country of origin
Test weight	Amylograph	Dockage

Table 1. Estimated Coefficients of the Non-linear Multinomial Logit Model: Japanese market

Coefficients on wheat and flour price variables

Factor	Factor level	Coefficient (std.err)	Factor level	Coefficient (std.err)	Factor level	Coefficient (std.err)
	Hard wheat		**Semi-hard wheat**		**Medium wheat**	
Effect coded Price	2% down	0.65*	2% down	0.83*	2% down	0.70*
		(0.19)		(0.18)		(0.19)
	1% down	0.16	1% down	0.06	1% down	0.20*
		(0.18)		(0.18)		(0.19)
	No change	-0.07	No change	-0.31*	No change	-0.17
		(0.19)		(0.19)		(0.19)
	1% up	-0.74*	1% up	-0.57*	1% up	-0.72*
		(0.21)		(0.21)		(0.20)

Coefficients on flour price variable

	Udon flour		**Drynoodle flour**		**Fresh Ramen flour**		**Instant Ramen flour**	
Effect coded Price	2% down	0.58*	2% down	0.10	2% down	0.30*	2% down	1.03*
		(0.19)		(0.18)		(0.18)		(0.18)
	1% down	0.51*	1% down	0.58*	1% down	0.38*	1% down	0.43*
		(0.17)		(0.17)		(0.17)		(0.17)
	No change	-0.29*	No change	0.06	No change	-0.07	No change	-0.16
		(0.19)		(0.18)		(0.18)		(0.18)
	1% up	-0.80*	1% up	-0.73*	1% up	-0.60*	1% up	-1.30*
		(0.21)		(0.20)		(0.19)		(0.22)

Table 2. Estimated Coefficients of the Non-linear Multinomial Logit Model: Japanese market

Coefficients on wheat quality factors

	Hard wheat		**Semi-hard wheat**		**Medium wheat**	
Factor	Factor level	Coefficient (std.err)	Factor level	Coefficient (std.err)	Factor level	Coefficient (std.err)
Ash content						
	1.90%	-1.02*	1.85%	-1.16*	1.85%	-1.40*
	1.75%	-0.39*	1.70%	-0.52*	1.70%	-0.78*
	1.60%	0.84*	1.55%	0.54*	1.55%	1.12*
	1.45%	0.75*	1.45%	1.13*	1.45%	1.07*
Falling No.						
	250	-0.95*	250	-1.46*	250	-0.96*
	300	0.57	300	0.23*	300	0.07
	337	0.42*	337	0.67*	337	0.26*
	380	0.48*	380	0.56*	380	0.63*
Test weight						
	73	-1.63*	75	-0.95*	75	-0.60*
	77	-0.39	77	-0.04	77	-0.20*
	80	0.68*	80	0.53*	80	0.42*
	84	1.00*	84	0.46*	84	0.38*
Protein						
	10.8%	-0.90*	9.5%	-0.78*	8.5%	-0.30*
	11.5%	-0.37*	10.2%	-0.46*	9.0%	-0.06
	12.2%	0.59*	10.7%	0.73*	9.5%	0.24*
	12.8%	0.69*	11.5%	0.51*	10.0%	0.13
Country of Origin						
	The U.S.	0.36*	The U.S.	0.12	The U.S.	-0.12
	Canada	0.21*	Canada	0.04	Canada	-0.47*
	Australia	-0.12	Australia	0.17*	Australia	0.37*
	Domestic	-0.46*	Domestic	-0.32*	Domestic	0.22*
Dockage						
	0.8	-0.80*	0.8	-0.83*	0.8	-1.14*
	0.6	-0.27*	0.6	-0.41*	0.6	-0.32*
	0.4	0.28*	0.4	0.30*	0.4	0.41*
	0.2	0.81*	0.2	0.94*	0.2	1.06*
Log likelihood function			-726.89			
Log likelihood ratio test (c^2 statistic)			589.66*			
Pseudo R^2			0.29			

Table 3. Estimated Coefficients of the Non-linear Multinomial Logit Model: Japanese Market

Coefficients on Flour quality factors

	Udon flour		**Drynoodle flour**		**Fresh Ramen flour**		**Instant Ramen flour**	
Factor	Factor level	Coefficient (std.err)	Factor level	Coefficient (std.err)	Factor Level	Coefficient (std.err)	Factor level	Coefficient (std.err)
Ash	0.50%	-1.83*	0.55%	-1.17*	0.50%	-1.50*	0.50%	-1.58*
		(0.25)		(0.20)		(0.22)		(0.23)
	0.42%	-0.14	0.48%	-0.58*	0.48%	-0.17	0.42%	0.22*
		(0.19)		(0.19)		(0.18)		(0.18)
	0.38%	0.68*	0.42%	0.29*	0.42%	0.32*	0.38%	0.42*
		(0.18)		(0.16)		(0.16)		(0.17)
	0.35%	1.29*	0.35%	1.46*	0.35%	1.35*	0.35%	0.94*
		(0.19)		(0.18)		(0.18)		(0.18)
Color								
	89	-0.55*	89	-0.34*	89	-0.16*	90	-0.24*
		(0.21)		(0.20)		(0.19)		(0.18)
	91	0.21*	90	0.09	90	0.28*	91	0.08
		(0.19)		(0.18)		(0.18)		(0.18)
	93	0.35*	92	0.12	92	-0.09	92	0.09
		(0.18)		(0.18)		(0.18)		(0.17)
	95	-0.01	93	0.13	93	-0.03	94	0.07
		(0.18)		(0.17)		(0.17)		(0.17)
Amylograph								
	250	-1.69*	250	-0.89*	250	-1.02*	250	-1.17*
		(0.24)		(0.20)		(0.20)		(0.21)
	300	-0.14	300	-0.31*	300	-0.28	300	-0.17
		(0.18)		(0.17)		(0.17)		(0.18)
	400	0.50*	400	0.19*	400	0.18*	400	0.24*
		(0.19)		(0.17)		(0.18)		(0.18)
	500	1.32*	500	1.01*	500	1.12*	500	0.11*
		(0.21)		(0.18)		(0.19)		(0.19)
Log likelihood function			-1001.13					
Log likelihood ratio test (c^2 statistic)			731.08*					
Pseudo R^2			0.27					