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Protein Demand in Hard Wheats

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Abstract

Wheat protein is one of the most important specifications used in domestic and import purchase contracts. It is used as a proxy for functional quality that is important in domestic markets and to importers. Large differences exist in functional characteristics amongst wheat that vary by protein level and class. The purpose of this paper is to analyze the demand for wheat protein across importing countries and through time. A choice based econometric model is specified and estimated using a pooled data set of wheat shipments. Results indicate that there have been shifts over time, purchase probabilities are highly price elastic and vary across importing regions. In addition, income, traded goods, urbanization, females in the work force, and domestic wheat production all impact purchase probabilities. Finally, wet gluten content and extraction rates have significant impacts on purchase probabilities.

Key Words: Wheat Quality, Protein, Hard Red Spring, Hard Red Winter, Market Segments

Protein Demand in Hard Wheat

William W. Wilson, Wesley W. Wilson, and Bruce L. Dahl [1, 2]

Introduction

There has been an increase in differentiation in many grain commodities over time, particularly as these markets mature and new technologies are introduced. In hard wheat, one of the important sources of differentiation is that of the protein level which is an easily measured proxy for desired functional characteristics. Hard red winter (HRW) and spring (HRS) wheat are the largest classes exported from the Untied States and the differentiation within these classes is primarily by protein level. Premiums exist for protein in these classes which are important to buyers, handlers, growers, and breeders. Premiums exist because protein level is correlated with functional traits (e.g., farinograph absorption) demanded by buyers. In recent years there has been an increase in this premium, though it is highly variable over time.

There is substantial variability in the demand for wheat protein which varies across countries and through time. Some countries routinely buy higher protein wheat, others lower protein wheat, and others switch frequently. In some cases, importers may buy combinations of each within a crop year. Exporting countries and regions compete vigorously on the level of protein content.

The shift toward privatization of wheat imports is another factor affecting changes in quality purchased (Wilson 1996a,b). An implication of privatization is a tendency for more specificity in purchase contracts. Generally, private buyers have a greater incentive to evaluate the value of higher quality and are more willing to pay premiums (and discounts) if that greater (lower) quality enhances (reduces) their profits. Importer procurement strategies, i.e., the combination of price and quality specifications, are critical factors in the HRS wheat market with some importers using more stringent contract specifications than U.S. domestic millers. [3] The latter are accustomed to mixing and blending and can target specific producing regions for their wheat procurement. Contract specifications have considerable strategic importance, particularly in view of competition among buyers (Johnson, Wilson, and Diersen 2001). In addition to wheat protein, a few countries have been working to purchase identity preserved shipments and/or varieties. These include Wharburtons from the Canadian Wheat Board (Kennett et al. 1998) and General Mills in the United States (Taylor, Brester, and Boland 2005).

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[2] A companion study by Dahl and Wilson (2000, 2004), "Grades/Classes of Hard Wheat Exported from the United States: Analysis of Demand and Trends 1986-2003," provides a detailed analysis of trends in exports by grade, class, and protein, and defines market segments in the international market.

[3] See Johnson, Wilson, and Diersen (2001) for a summary of export specifications of major hard wheat importing countries.

The purpose of this report is to analyze the demand for wheat protein in hard wheat exports from the United States. A pooled data set of individual wheat shipments is used to analyze purchase decisions in a choice based econometric specification. This paper is motivated by a number of factors. First, there has been an increase in prices for higher protein wheats in recent years, which are highly variable and may impact demands. Second, existence of unique demands by protein levels suggests the existence of market segments and has implications for marketing strategies. Finally, buyers' response to quality and other factors has important implications for breeders. In particular, breeders continuously try to improve functional characteristics which can be interpreted as an effort to increase purchase probabilities, but this is done at a tradeoff relative to yields (Dahl, Wilson, and Nganje 2004).

The first section summarizes relevant previous studies and then we present some background data. The model specification is then described and results and economic interpretation are described. The paper makes several contributions. First, it extends previous studies using hedonics and other models that analyze the role of quality in trade. The difference, however, is that here we analyze how factors impact purchase probabilities, instead of measuring the implicit price of measurable characteristics. Second, it provides a choice based econometric specification that can be used to analyze purchase decisions. Finally, it explores the evolving segments in the world wheat market which have evolved to become highly differentiated across countries, classes, physical attributes, and implicit characteristics.

Previous Studies

Wheat has numerous end uses and indigenous characteristics. Wilson (1989) demonstrated that over time, differentiation (using the Hufbauer index) has increased. Hedonic studies generally have similar conclusions. [4] Wilson and Gallagher (1990) and Wilson (1989) indicated that through time, there has been a growing diversity of demands for end-use characteristics. Class differences have been recognized and were the focus of earlier analysis in broader policy models (Agriculture Canada 1987; Wang 1962; Chai 1972; Chang 1981; Benirschka and Koo 1995; Wilson 1994).

Most major wheat exporting countries have been analyzing institutions impacting exports and quality. In Canada, much of the debate has been on topics related to kernel visual distinguishability (KVD). Varieties are classed using visual techniques, and this system has been challenged due to its high cost and that it inhibits productivity. Results of recent studies have analyzed the costs (Furtan, Burden, and Scott 2003) and benefits (Oleson 2003) of alternatives. The Grains Council of Australia conducted a series of studies on the international market (Grains Council of Australia 1995). Conclusions indicated a large portion of the variability in prices received by the Australian Wheat Board were due to variability in quality characteristics. Further, it suggested that Canada and Australia were thought to be "quality suppliers" and the United States, along with the European Union (EU), Saudi Arabia, and Argentina, were price suppliers. More recently, Australia is evolving toward increased emphasis on niche marketing whereby varieties and production regions are being matched to customer

[4] There have been numerous studies using hedonic analysis in the international wheat market. These include Wilson (1989); Veeman (1987); and Wilson and Preszler (1992, 1993).

needs and the Golden Rewards Program was introduced to provide incentives (Australian Wheat Board 2005). [5] More recently, Argentina has studied their system with respect to differences between varieties and the inability to classify them according to functional differences (Cuniberti and Otamendi 2004).

The U.S. grading system measures physical (not chemical) characteristics, and these are the mechanisms upon which the establishment of quality measures for premiums and discounts rely. Hence, premiums and discounts develop and are critical as they provide signals to growers and breeders, as well as to buyers. In the United States, explicit premiums and discounts emerge for grain factors, protein, and dockage. In addition, in some cases, implicit premiums may emerge for varieties and/or other functional differences, though this is not at all common.

In an earlier study, Dahl and Wilson (2000) examined growth and trends for grades and classes of hard wheat exports from North America from 1986 to 1994. They found shifts toward increases in exports of higher grades for hard amber durum (HAD), HRS, and HRW wheat and an increase in heterogeneity of purchases by hard wheat importing countries. In a more recent study, Dahl and Wilson (2004) found trends continued with increases in proportion of higher grades of HRS and HAD wheat purchased, while HRW wheat remained similar to their prior analysis. Cluster analysis for each class found there were changes in number and composition of segments. Higher quality segments had reduced dockage content and there were increases in the proportion of purchases specifying protein. Shares of export volume for the highest quality segments for HRS and HAD wheat doubled in size.

Young (1998) evaluated trends in wheat grades and classes for U.S. wheat. She observed changes in the classes of wheat exported with HRS wheat increasing in importance and HRW wheat decreasing. There were increases in exports of No. 1 HRS, HRW, and, to a lesser extent, White Wheat. The increases in exports of hard red wheats were primarily attributed to South Korea and Mexico. She compared quality parameters for wheat in eight countries that had procured through state agencies and private traders and found no noticeable patterns in quality data that would indicate private buyers purchase higher quality than state agencies.

Lavoie (2003) analyzed the effects of reform of STEs on imports of a quality-differentiated product. She assumed higher quality wheats were differentiated by source. All wheat from Australia and Canada sources were considered high quality which contrasts with the fact that there is poorer quality of wheat produced in each of these countries. Her results indicate that after reform of an STE, imports of both higher and lower quality wheats should increase and domestic production should decline. Trends for selected importing countries that had reformed STEs tend to indicate increases in imports of both high and low quality wheat using the definition of high quality as those imported from Australia and Canada. Similar results were found for South Korea for U.S. exports where higher grades increased after reform of their STEs.

World Perspectives Inc. (2003) indicated global demand for milling quality wheat has begun to decline, offset by growth in lower quality, lower priced feed wheat demand.

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[5] See Drynan (1998) for a recent summary of export strategies with respect to quality in each of Australia and Canada. The Golden Rewards Program is discussed at http://www.awb.com.au.

Production of higher quality wheat in Canada and the United States has been declining, while production has increased in non-traditional exporters such as Ukraine, Kazakhstan, Russia, India, etc. They define higher quality wheat demand as total wheat food consumption (total consumption less feed consumption). Thus, their analysis is more comparable to trends in wheat classes.

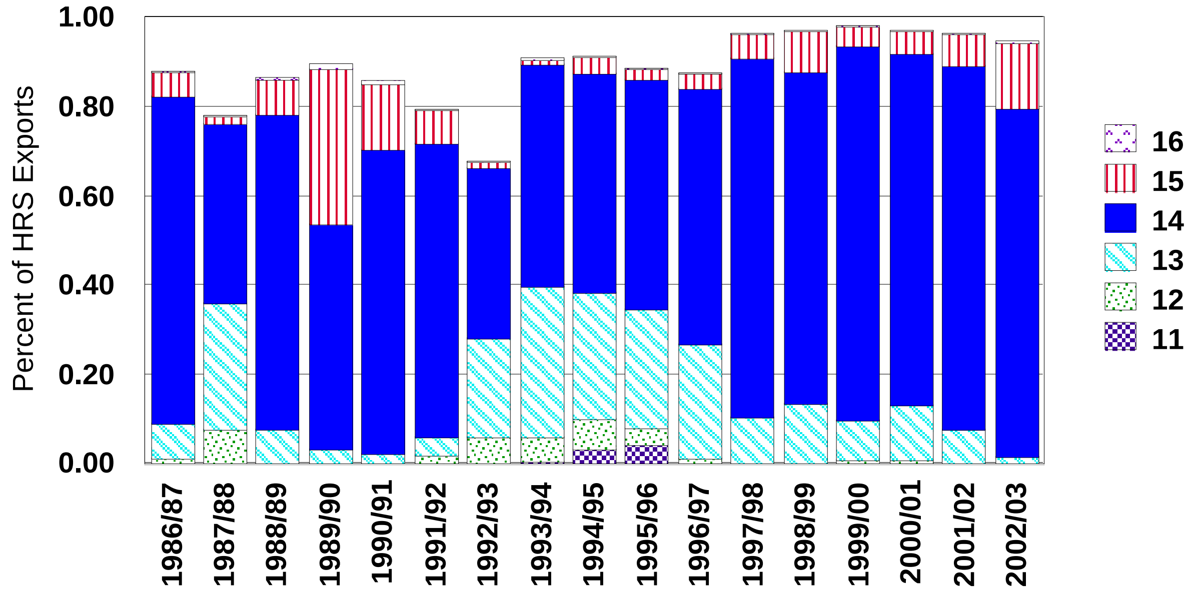
Wheat Exports and Functional Characteristics

Wheat Exports by Protein

A data set was developed on characteristics of U.S. wheat export shipments. Data were from the U.S. Department of Agriculture, Federal Grain Inspection Service, Grain Inspection Packers and Stockyard Administration (USDA-FGIS-GIPSA) from 1986-2003 for individual export shipment inspections. These included information on wheat class, grade, grade characteristics (test weight, moisture, foreign material, damaged kernels, total damage, wheat of other classes, and wheat of contrasting classes), protein, dockage, volumes, and destinations. Following is a brief summary of the behavior of these data.

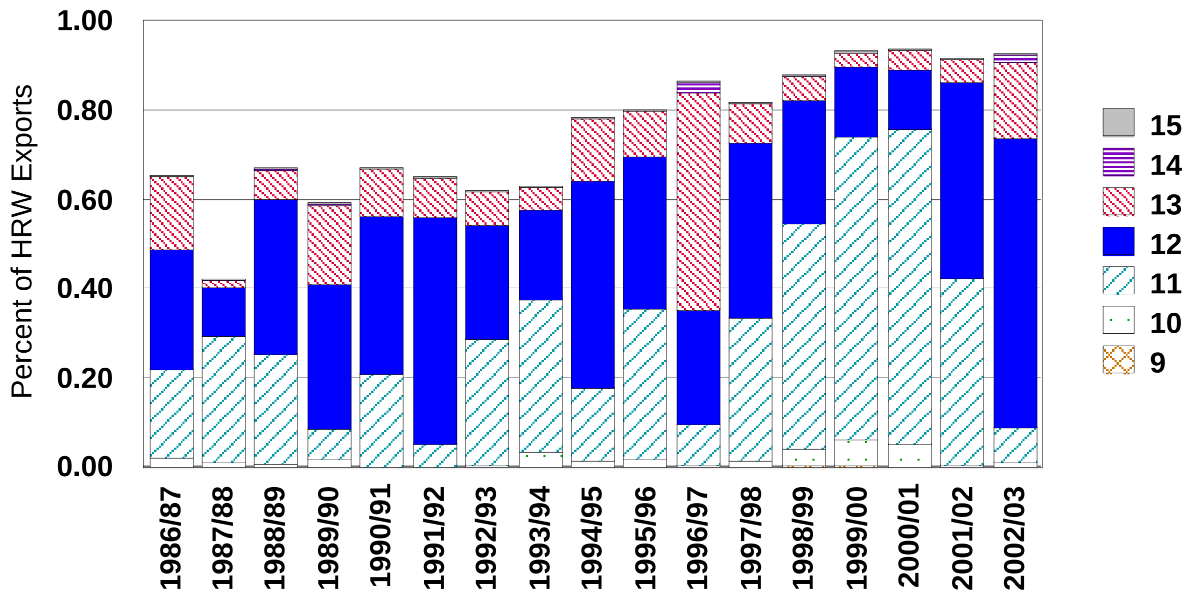
HRS wheat exports by protein level have changed from periods where exports less than 14% protein accounted for up to 40% of exports, to periods where lower protein HRS wheat accounted for minimal exports (Figures 1 and 3). Periods of high levels of lower protein exports occurred both in 1987/88 and the period comprising the early to middle 1990s. Shares of exports for HRS wheat with less than 14% protein have since declined to less than 13% of exports in most of the 2000s and a low of 1.5% of exports for 2002/03. Reductions in HRS wheat exports for lower protein wheats were generally replaced by exports with 14.0%-14.9% protein. It is notable that since 1996/97, more than 94% of export volumes had protein specified and the average level of protein exported was 14.2%. Prior to then, protein was specified on 80% of export volumes and the average level was 14.1%. The exceptions are for 1987/88 and 1992/93 when only 78% and 67% of export volumes specified protein.

Specification of protein for HRW wheat exports has trended higher, increasing from a low of 41% of HRW wheat exports in 1987/88 to more than 90% in the 2000s (Figure 2). For HRW wheat, the increase in exports that had protein less than 12%, which had been less than 40% of export volume prior to 1998/99, peaked at just less than 80% of exports in 2000/01 and has since declined. This decline in exports of protein less than 12% was largely replaced with 12%-12.9% protein exports. These observations contrast sharply with Young (1998), in that, more buyers are now specifying protein level.



Note: 11 is 11-11.9, 12 is 12-12.9, 13 is 13-13.9, 14 is 14-14.9%, 15 is 15-15.9%, and 16 is 16 or more
Does not add to 100% as excludes shipments with unspecified protein levels

Figure 1. Percent of HRS Exports by Protein Level, 1986/87 to 2002/03



Note: 14 is 14-14.9%, 15 is 15-15.9%
Does not add to 100% as excludes shipments with unspecified (ordinary) protein levels

Figure 2. Percent of HRW Exports by Protein Level, 1986/87 to 2002/03

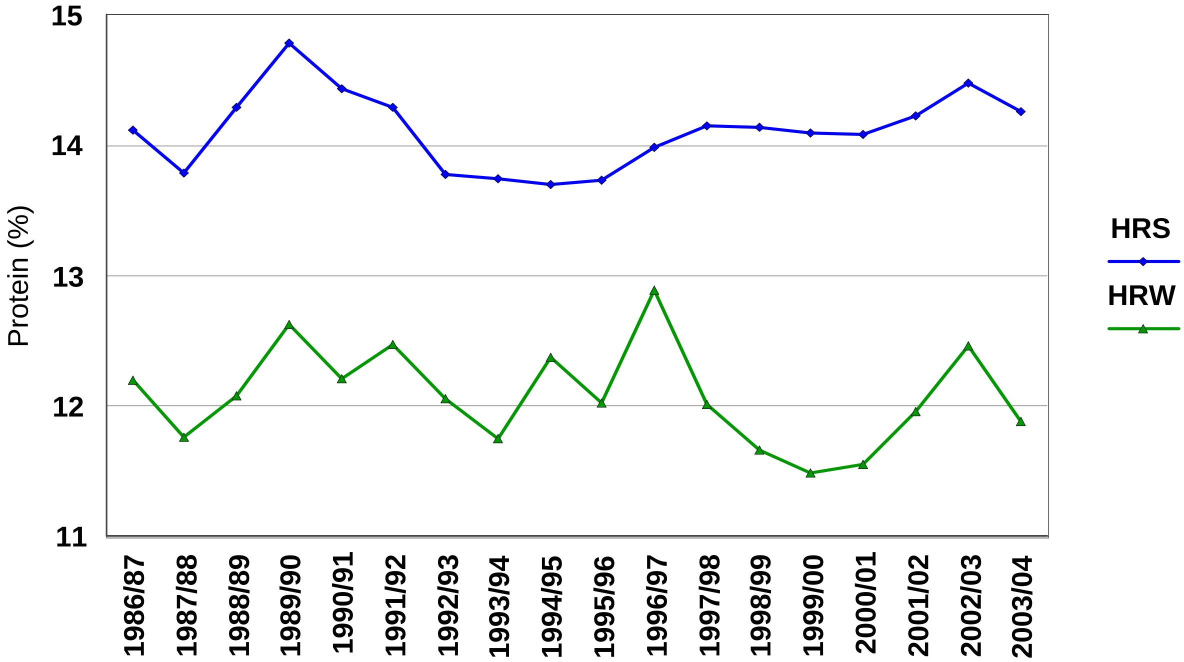


Figure 3. Average Protein Level for Exports by Wheat Class, 1986/87 to 2003/04

Average protein levels for U.S. HRS wheat exports over the period 1998/99 to 2002/03 were derived for individual countries. Those importing lower protein HRS (<14%) were largely from Africa and Asia, but also included Norway, Indonesia, and the Philippines. Countries importing high protein wheat were largely from Western Europe and Southeast Asia, but also included Uzbekistan and Cuba. For HRS wheat, China and Costa Rica showed increasing trends toward higher protein levels from the early 1990s to 2002/03 (Figure 4). Taiwan, Japan, and Korea showed trends that reflect a shift toward less variability from year to year in average protein levels, although Taiwan increased their average level of protein to 14.5% in 1996/97 so that their imports are generally .5% higher than Japan and Korea. Protein levels for Belgium imports have fluctuated, although they remain one of the highest of any U.S. HRS wheat importing country. Exports of HRS and HRW wheat show increases in the proportion of exports shipped at higher protein levels and increases in the proportion of exports where protein is specified. The increase in the proportion of exports where protein is specified was greatest for HRW and HRS wheat.

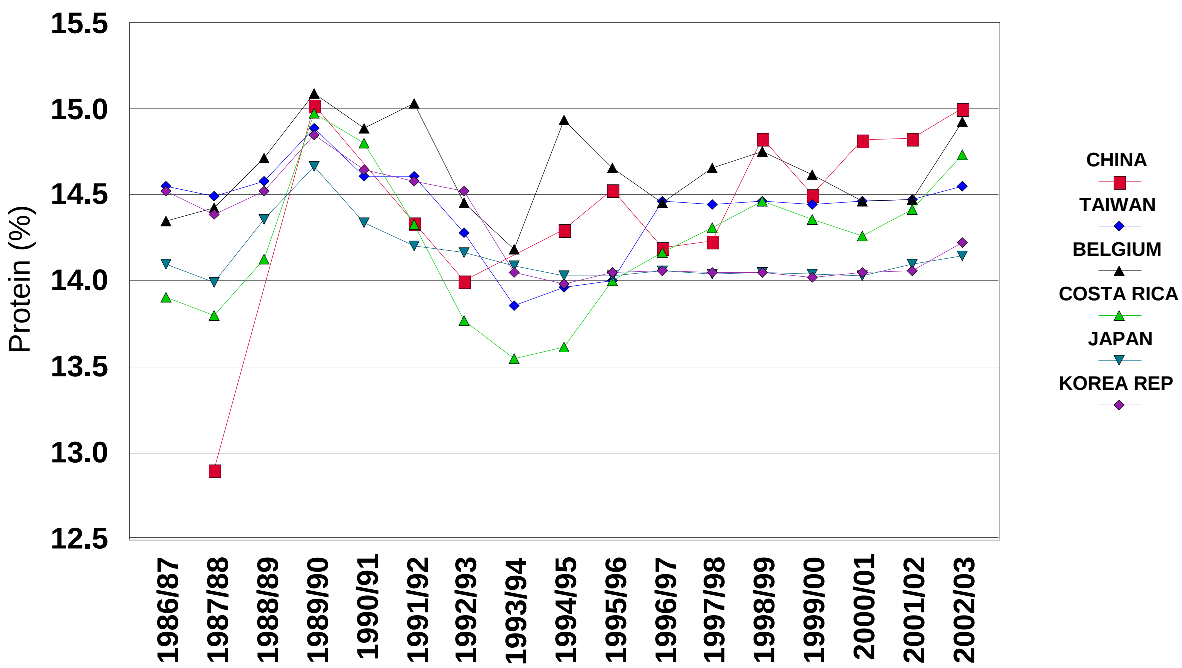


Figure 4. Average Protein Level for U.S. HRS Exports, Selected Importing Countries, 1986/87 to 2002/03

Functional Characteristics and Wheat Protein

End users specify hard wheats of different protein levels because of their underlying functional characteristics. These include falling numbers, wet gluten, various farinograph measures including stability and peak time, as well as absorption and extraction rates. Generally, these functional characteristics are required to produce the types of products requiring higher gluten content (Wheat Marketing Center 2004). The exact value required varies by product and process and would typically differ in different importing countries. Some products require fairly high absorption and stability levels, whereas other products or processes can use lower levels. Typically, though not always, values for these functional characteristics are used as either explicit contract terms between millers and bakers or form an expectation based on previous experiences. These demands for functional characteristics are generally impossible to observe and vary across countries and customers.

Functional characteristics are typically not measured within the marketing system (with the exception of falling numbers). Instead, wheat protein which is easily and routinely measured in the marketing system is used as a proxy for these desired end-use characteristics. Hence, buyers specify protein requirements which vary by type of product and process. In some cases, they may choose not to specify protein. In others, they specify protein levels that vary with the products intended to be produced from the product. For example, one buyer may specify a higher value of protein because they need a higher loaf volume or absorption, whereas another may require a lower level of wet gluten and would specify a lower protein. These functional characteristics are not observed in trade data. However, they are important, their values are apparent from previous purchases and are reflected in crop quality reports that are widely distributed. There are some experiments under way in which buyers are specifying limits or desired levels of selected functional traits in their purchase contracts.

To illustrate, Tables 1 and 2 show the mean and correlations between wheat protein by class and the underlying functional characteristics.

Table 1. Functional Characteristics by Class

Variable	HRW	HRS
Falling Number	432	363
Wet Gluten	27	35
Absorption	60	64
Peak Time	6	10
Tolerance	12	15
Loaf Volume	785	927
Extraction Rate	71	70

Table 2. Correlation of Protein and Selected Quality Characteristics (HRS and HRW Export Cargo Survey Data, 1985-2004)*

	Protein	Fall Number	Wet Gluten	Absorp.	Peak Time	Tol.	Loaf Vol	Extract Rate	Flour Ash
Protein	1	-0.41	0.95	0.78	0.70	0.57	0.71	-0.64	
Fall No		1	-0.41	-0.35				0.34	0.34
Wet Gluten			1	0.78	0.63	0.49	0.74	-0.71	
Absorp				1	0.60	0.42	0.56	-0.54	
Peak Time					1	0.86	0.36	-0.48	
Tol.						1	0.34	-0.33	
Loaf Vol.							1	-0.43	0.40
Extract. Rate								1	
Flour Ash									1

Correlations estimated from annual export cargo survey data, 1985-2004, for HRS and HRW contained in U.S. Wheat Associates' Crop Quality Reports.
* Only statistically significant (p<.05) correlations are reported.

These correlations were estimated from annual average values for export cargo surveys 1985-2003(4) for HRS and HRW using observations for both by port area (PNW and Gulf for HRW wheat and PNW, Gulf, and Lakes for HRS wheat) (U.S. Wheat Associates, various years). Years for HRS wheat were only available from 1985-2003, while for HRW wheat the years available were from 1985-2004. Only correlations that were statistically significant were reported. Strong correlations exist between protein and wet gluten, yet protein is negatively correlated with extraction rates. Wet gluten has stronger correlations with absorption, peak time, and tolerance. Extraction rates are negatively correlated with these same characteristics. Correlations for HRW and HRS wheat estimated separately are contained in Appendix Tables 1 and 2.

Model Specification

We model importer decisions to purchase wheat classes and protein levels as a choice model. The choice set are five class and protein categories W-Ord, W-13, S-13, S-14, and S-15 where W and S stand for HRW and HRS wheat, respectively, and the numerical values indicate the protein level. The choice set is indexed by $c=1,2,\ldots,C$. Importers are taken to make utility maximizing choices. For a particular class/protein category (k) to be chosen, it must satisfy $U_k \geq U_c$ for all c.

Utility consists of two components, an observed deterministic component and an unobserved component: $U_{ci} = x_{ci}^T \beta_c + \varepsilon_{ci}$, where c represents the choice and I represents the observation. The deterministic component is $x_{ci}^T \beta_c$ and ε_{ci} represents the unobserved component. The probability that choice k is observed is $\Pr b(U_{ki} > U_{ci})$ which is $\Pr b(x_{ki}^T \beta_k - x_{ci}^T \beta_c \geq \varepsilon_{ki} - \varepsilon_{ci})$.

Further clarification is warranted about our data and specification. The data consists of observations that include attributes which vary across the choice made and attributes of the importing countries that do not vary across the choice set. With respect to the former, the attributes include prices of the choices (P_{ci}) and variables representing expected values of functional characteristics (F_{ci}) for that class and protein choice.

In addition to attributes that vary across the choice set, we also observe a set of variables that vary across the choice-maker. These include impacts of macroeconomic and demographic variables including income, domestic wheat production, urbanization, women in the work force, and traded goods. In addition, an intercept (termed the alternative specific dummy) and regional dummy variables were included, as well as a trend (t) as 1 in 1986, 2 in 1987, etc.

The general model we estimate with reference to specific types of variables is specified below. First, for clarity of reference, let c,p,i,t represent the class, protein level, imported by country I at time t.[6] With this notation, the choice is a function of the intercept, a time trend, prices of each alternative, functional characteristics, and a set of importer characteristics which are represented in the following utility function:

[6] There are often multiple trades by a country during any given year. These may or may not be within the same class/protein level. While grouped logit techniques could be explored, the programs used simply replicate the proportions and the total number of trades to reflect the nature of the data used here.

$$U_{cpit} = \alpha_{cp} + \delta_{cp}\, t + \beta^P\, P_{cpit} + \beta^F_{cp}\, F_{cit} + \beta^I_{cp}\, I_{it} + \varepsilon_{cpit}$$

where:

α_{cp} = The effect of alternative specific intercepts measured relative to W-Ord;

δ_{cp} = The effect of the time trend measured relative to W-Ord;

β^P = The effect of the price of class and protein level *c,p* at time *t* faced by importer *I;*

β^F_{cp} = The effect of functional characteristics (F) which may vary across class and protein (*cp*);

β^I_{cp} = The effect of variables that vary across importers (*I*) over time (*t*, the response may vary across class and protein (*c,p*).

The model specification is a general representation which encompasses other specifications which are special cases of this equation.

A model based on attributes which vary across the choice set is a conditional logit. A model based on attributes which are constant across the choice set but vary across the decision-maker is a multinomial model. Such differences are largely terminological, but are useful here to delineate the two different types of variables.

In this choice framework, all variables that do not vary across importers disappear as the choice is made on the basis of differences in utility functions. If the response of each choice differs across the alternatives (i.e., a different β for each alternative), then estimation proceeds by normalizing the coefficient vector with respect to one of the alternatives. The parameters and marginal effects are then measured and interpreted relative to that alternative. In our case, we normalize with respect to W-Ord. The straight conditional logit model is obtained if the alternative specific dummy variables, the trend (interacted with the alternative specific dummy variables), and the importers' specific characteristics are each jointly equal to zero. The multinomial logit model is obtained if the effect of price and functional characteristics are zero. In the end, we estimate at *hybrid* model that allows for each type of effect. Specifically, the model contains variables that vary across the choice (price) and variables that vary only across the importers (e.g., per-capita income).

Marginal effects are presented for each of the relevant variables. For variables that vary across the choice (e.g., price) denoted for this purpose as x_c , the conventional notation for the marginal effect is $\frac{\partial \Pr b_j}{\partial x_c} = (\Pr b_j)(1(j = c) - \Pr b_c)\beta$ for c=1,...,C where β is the coefficient on x_c. The marginal effect has the same sign as the coefficient. For variables that vary across importers but not across choices denoted for this purpose as x_i , the notation for the marginal effect is $\frac{\partial \Pr b_c}{\partial x_i} = (\Pr b_c)(\beta_c - \sum_{k=0}^{C} \Pr b_k \beta_k)$. In this case, the marginal effect need not have the same sign as the coefficient. Finally, some specifications include discrete right-hand side variables. For these variables, the marginal effect is calculated by the difference in predicted probability schedules at median values of the continuous variables.

While these parameters have conventional interpretations regarding choice, those of the functional characteristics are particularly important. The values for β_{cp}^{F} represent the impact of a change in the functional characteristics on the choice by the importer. A longer term objective of breeding programs is to improve these values, which are also proxies for other values, and these coefficients represent the impact of functional quality improvement on purchase probabilities.

Data Sources and Behavior

The primary data set is from the USDA-EGIS (Export Grain Inspection System) of the FGIS. Variables included in this data set are detailed ship-lot grade and grain characteristics. For each shipment it contains grade, class protein level, whether protein is specified, as well as individual grade and non-grade determining factors as reported by the FGIS. It reports this for each shipment to each of importing country.

The data set contains 47,759 shipments of wheat that occurred between 1983 and 2003. The data were not reliable prior to 1986, so we omitted 6,775 observations (trades that took place prior to 1986). We omitted 1,156 observations that occurred in 2003, because some importer characteristics (described below) were not available after 2002. The analysis is for the HRS and HRW wheat classes which, combined with the other adjustments, had the effect of reducing the number of observations to 24,954 observations.

Our primary concern relates to determinants of importing country choices between HRS and HRW wheat over time with respect to specific protein categories. Over the time period of our study, HRS and HRW wheat represented 30% and 33% of wheat exports from the United States, respectively. The protein categories are class dependent. For HRW, we identify two protein categories. These are protein levels 13 for average protein in the lot being 13% or higher and “Ord” for average protein levels less than 13%. For HRS wheat, we identify three categories. These are 13, 14, and 15% for average protein levels less than 14, 14-15, and 15% or higher. In addition for observations in which protein is not specified, we assign it a value equal to the lowest category in each class.

Distributions of the class/protein categories are summarized in Table 3. There were a number of observations for which protein levels were not observed in the data. The average protein level of the lot was only recorded if the importer requested it. In cases of non-requested recordings, the lots are most often the lowest protein category, and we added those to that category. However, given the relatively low cell counts, we opted to omit these observations which reduces the number of observations to 23,282.

Table 3. Class and Protein Frequencies [a]

Class/Protein	Frequency	Percent
HRS-13	1,647	7
HRS-14	7,448	32
HRS-15	1,158	5
HRW-13	1,515	7
HRW-Ord	11,514	49
Total	23,282	100

[a] There are 1,672 observations for which the average protein level was higher (in the case of HRW wheat) than the categories permit or lower (in the case of HRS wheat). These relatively unusual observations were dropped from further analysis. These observations could be wrapped into the other categories or other categories could be added to reflect these observations. However, given the relatively low cell counts, we opted to omit these observations.

Our econometric model focuses on choices made by importer countries for the class and protein level. We explain these choices with a set of attributes which apply to the choice made, e.g., prices and functional characteristics, a set of attributes which apply to the importing country, and a trend. Prices are available for each class/protein category described above. They are not, however, available at the same location. In our case, we used prices for HRS wheat (13, 14, 15) at Minneapolis, and prices for HRW wheat reflect prices at Kansas City. Alternatives would be to use port prices, but no consistent series over time and across all choices was available. Since prices enter the econometric model as relative prices, use of these more comprehensively available prices was preferred. Prices were deflated by the producer price index for wheat. [7] A summary of prices (in real terms) for each of the choices is in Table 4 and Figure 5. Over the span of years, the average premiums for HRS wheat vary as opposed to HRW wheat and for higher protein levels (as expected). Prices vary across class/protein categories over time, but not across observations in a given year. Over time premiums peaked out in 1993 and 1995, then declined and increased in the most recent year (Figure 5).

[7] Evaluation of alternative deflators (the all inclusive PPI, farm price PPI, grain price PPI, and wheat price PPI), suggested that the latter tracked the pattern of prices best.

Table 4. Prices for Class and Protein Levels by Year

	HRW-Ord	HRW-13	HRS-13	HRS-14	HRS-15
1986	2.72	2.87	2.85	3.07	3.51
1987	2.96	3.14	2.98	3.15	3.68
1988	4.17	4.23	4.32	4.36	4.44
1989	4.22	4.21	4.15	4.16	4.17
1990	2.94	3.01	3.04	3.06	3.24
1991	3.77	3.77	3.82	3.82	3.91
1992	3.67	3.74	3.75	3.91	4.73
1993	3.60	4.40	4.35	5.02	6.11
1994	3.97	4.06	4.11	4.26	4.73
1995	5.49	5.69	5.64	5.72	5.94
1996	4.88	4.92	4.89	4.97	5.41
1997	3.71	3.96	4.20	4.31	4.49
1998	3.08	3.49	3.71	3.83	4.11
1999	2.87	3.41	3.40	3.65	4.05
2000	3.30	3.48	3.45	3.62	3.95
2001	3.25	3.35	3.53	3.61	3.74
2002	4.22	4.24	4.45	4.47	4.51
Average	3.89	4.10	4.14	4.29	4.66

There are a number of functional characteristics in each wheat class including loaf volume, absorption, wet gluten, extraction, fall number, peak time, tolerance, and flour ash. These are reported in Table 1 and their correlations are in Table 2. These represent characteristics that vary across class category, through time, and by region of export which can be tied to each trade in the EGIS data set. In terms of choices, these variables reflect characteristics of a class category which explain, at least, part of the vertical differentiation between the classes. The observed quality characteristic *per se* indeed affects importers' decisions. Generally these should positively influence choices. If the characteristic increases and/or is greater for a possible choice relative to other possible choices, the probability of the former should be larger. Further, the marginal effect may not be symmetric across protein levels. A characteristic may be very important for S-14 or S-15, but not important at all for other categories.

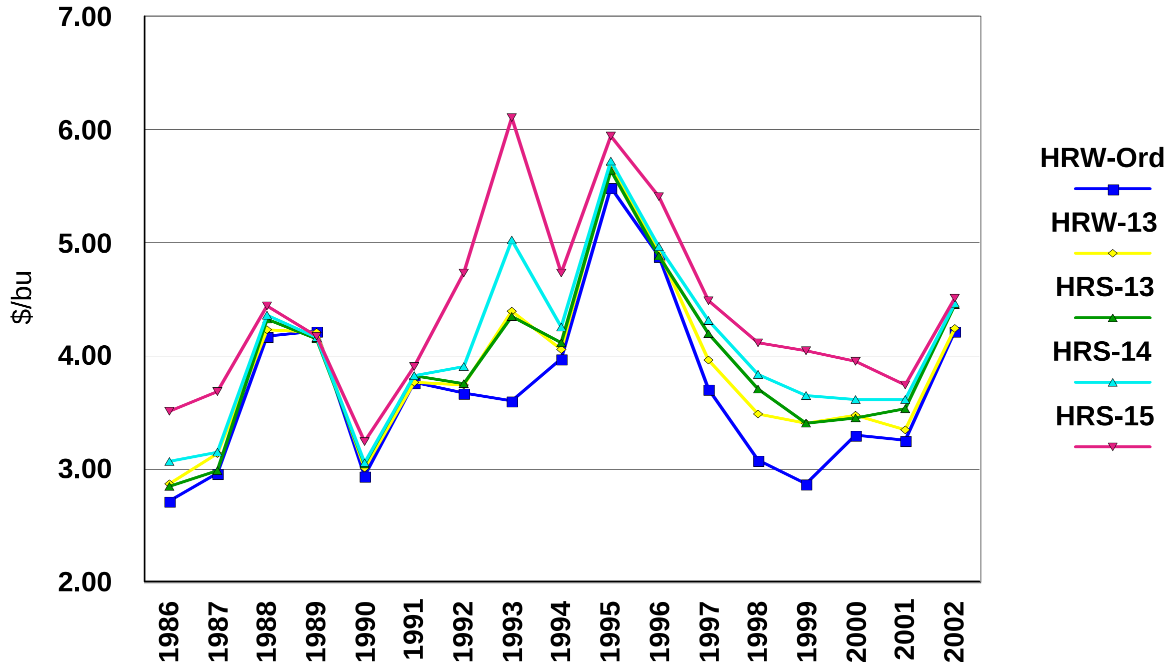


Figure 5. Average Marketing Year Price by Class and Protein, 1986/87 to 2002/03

The final set of variables (apart from trend and regional dummy variables) relates to a set of importer characteristics. These are macroeconomic indicators and/or demographic variables that may impact preferences and choices. These vary across importers and through time, but not across the choice set. We include these to reflect different preferences and import patterns across countries. Numerous variables could be included, and inclusion rested on two principles. Variables were included if trade patterns or theory required their inclusion. These included per capita income, wheat production in the importing country, and imports from Canada. Finally, we include traded goods to capture a measure of a country's macro dependence on trade.

A second class of variable was included to reflect differences in preferences. These included a dummy variable for the region which captures that differences may exist across regions. Second, we include urbanization and women in the work force to reflect notions of the demand for convenience, product choice, and impacts on grain import quality decisions. Several organizations point to the role of these variables on the demand for quality (Courtmanche 2004; Lohmar 2004; ProExporter 2005a,b) but their impact is not well understood empirically.

A summary of all continuous variables considered is in Table 5. Data were obtained from World Bank (2004).

Table 5. Selected Importer Characteristics

Description	Mean	Std. Dev.
GDP Constant $ US	1,441,549.0	2,630,664.0
Percent of Labor Force Female	36.8	6.2
Trade in Goods	50.9	36.4
Urbanization	62.8	20.0
Women over 65 per man	131.0	20.2
Domestic Wheat Production	4,561.0	16,282.9

Empirical Results

Model Selection

A multinomial logit model is one in which the decision-maker has multiple alternatives from which to make a single choice. Variables that explain the choice vary across individuals, but not across alternatives. The econometrics proceeds with varying specifications, with inclusion of successively more variables, the purpose being model selection, and illustrates impacts of important variables. First we describe the models specified and the resulting final model and in the following section we provide an econometric interpretation of the results.

The first specification included intercepts, trends (Models 1 and 2 in Table 6) and prices (Model 3). The results suggest that over time the shares for S-15, S-13, and W-13 are declining, while S-14 and W-Ord are increasing. In addition, prices are clearly very important (Model 3) and their inclusion does not impact the trends.

Income and regional effects are added in Models 4 and 5 (Table 7). The latter were captured by adding regional dummies for Africa, Asia, CSAM, Europe, FSU, NAM, and Oceania with Asia as the “base” dummy. The results suggest strong price and income effects as well as regional effects.

Importer country attributes were added in Model 6 (Table 7). The importer attributes included were females in the workplace, urbanization, and traded goods as percent of GNP. Others were included but not retained due to insignificance. The effects of the importer attributes are all important. Increases in any of these increases the probability of the classes above. Model 7 added effect of domestic wheat production in the importing country. Domestic wheat production was added in Model 7 (Table 8).

Table 6. Impacts of Intercepts, Trend and Prices: Models 1-3

	Model 1			Model 2			Model 3		
Variable	Parameter	SE	T-Ratio	Parameter	SE	T-Ratio	Parameter	SE	T-Ratio
A_S15	-2.2969	0.0308	-74.504	-1.8891	0.0600	-31.484	-1.4559	0.0635	-22.912
A_S14	-0.4356	0.0149	-29.295	-0.6084	0.0324	-18.800	-0.4567	0.0334	-13.676
A_S13	-1.9446	0.0263	-73.816	-1.8704	0.0550	-34.023	-1.8345	0.0549	-33.403
A_W13	-2.0281	0.0273	-74.210	-1.7467	0.0547	-31.955	-1.6513	0.0548	-30.133
S15xTRE1				-0.0472	0.0063	-7.500	-0.0403	0.0063	-6.421
S14xTRE2				0.0183	0.0030	6.042	0.0319	0.0031	10.190
S13xTRE3				-0.0081	0.0053	-1.525	0.0071	0.0054	1.323
W13xTRE4				-0.0319	0.0055	-5.748	-0.0259	0.0055	-4.681
PRICE							-0.6642	0.0365	-18.221
Log L	-28572.9			-28491.8			-28316.2		

Table 7. Impacts of Incomes and Regional Effects: Models 4-6

	Model 4			Model 5			Model 6		
Variable	Parameter	SE	T-Ratio	Parameter	SE	T-Ratio	Parameter	SE	T-Ratio
PRICE	-0.6925	0.039	-17.776	-0.7525	0.042	-17.938	-0.735	0.0451	-16.301
A_S15	-1.6315	0.0712	-22.915	-1.3193	0.0853	-15.464	-6.1796	0.4068	-15.189
A_S14	-0.7491	0.0391	-19.176	-0.4153	0.0459	-9.041	-4.3311	0.1975	-21.932
A_S13	-1.6846	0.0604	-27.872	-1.579	0.0722	-21.869	-6.2386	0.2811	-22.196
A_W13	-2.7121	0.0742	-36.541	-2.4429	0.0895	-27.294	-3.4545	0.3919	-8.814
S15xTRE1	-0.0551	0.0065	-8.437	-0.0415	0.0069	-5.98	-0.1224	0.0086	-14.294
S15xGDP1	0	0.0000	20.477	0	0.0000	4.608	0.0001	0.0000	13.767
S14xTRE2	0.0185	0.0034	5.402	0.0381	0.0038	10.159	-0.0007	0.0043	-0.162
S14xGDP2	0.0001	0.0000	36.7	0	0.0000	20.51	0	0.0000	21.665
S13xTRE3	-0.0033	0.0055	-0.598	0.0045	0.0057	0.787	-0.0215	0.0066	-3.251
S13xGDP3	0	0.0000	1.568	0	0.0000	-1.342	0	0.0000	2.697
W13xTRE4	-0.037	0.0066	-5.581	-0.022	0.0068	-3.226	-0.072	0.0080	-9.039
W13xGDP4	0.0001	0.0000	40.952	0.0001	0.0000	28.53	0.0001	0.0000	26.646
S15xAFR1				-2.011	0.1872	-10.745	-1.8401	0.2382	-7.725
S15xCSA1				-0.006	0.0923	-0.065	1.3341	0.1259	10.598
S15xEUR1				3.0234	0.1134	26.65	3.4601	0.1269	27.274
S15xFSU1				-30.7051		0	-32.8363		0
S15xNAM1				-1.734	0.1687	-10.277	-0.4458	0.1980	-2.251
S15xOCE1				-28.6655		0	-30.1042		0
S14xAFR2				-1.8541	0.0729	-25.429	-1.4059	0.0864	-16.27
S14xCSA2				0.2538	0.0442	5.739	1.0371	0.0589	17.601
S14xEUR2				1.3901	0.0965	14.41	1.4968	0.1035	14.455
S14xFSU2				-4.3376	0.7111	-6.1	-33.4469		0
S14xNAM2				-2.4052	0.0848	-28.368	-1.8871	0.0946	-19.944
S14xOCE2				2.9314	1.0271	2.854	2.7439	1.0273	2.671
S13xAFR3				-0.4486	0.0854	-5.255	0.1331	0.0928	1.435
S13xCSA3				0.2464	0.0737	3.342	1.1814	0.0872	13.552
S13xEUR3				1.1279	0.1554	7.256	1.3159	0.1624	8.105
S13xFSU3				-2.0337	0.4555	-4.465	-3.4836	1.0127	-3.44
S13xNAM3				-0.5297	0.0882	-6.005	0.3461	0.0973	3.557
S13xOCE3				1.7395	1.4154	1.229	1.7057	1.4179	1.203
W13xAFR4				-0.0847	0.1152	-0.735	0.5881	0.1489	3.95
W13xCSA4				-0.3488	0.1209	-2.886	0.0154	0.1481	0.104
W13xEUR4				-1.1291	0.3165	-3.568	-0.9801	0.3202	-3.061
W13xFSU4				-1.9623	0.7141	-2.748	-0.4855	0.7345	-0.661
W13xNAM4				-0.9383	0.1305	-7.191	-0.4423	0.1476	-2.997
W13xOCE4				2.3473	1.2270	1.913	2.7213	1.2302	2.212
S15xLF_1							0.1149	0.0088	13.128
S15xTRG1							0.0309	0.0010	29.956
S15xURB1							-0.0256	0.0026	-9.844
S14xLF_2							0.0748	0.0043	17.464
S14xTRG2							0.0185	0.0008	21.888
S14xURB2							0.0024	0.0012	1.942
S13xLF_3							0.0919	0.0059	15.694
S13xTRG3							0.0234	0.0010	23.833
S13xURB3							-0.0033	0.0020	-1.671
W13xLF_4							-0.0123	0.0083	-1.479
W13xTRG4							0.0232	0.0011	20.865
W13xURB4							0.0014	0.0033	0.4128
Log L	-24356.4			-22335.7			-19576.5		

Table 8. Impacts of Domestic Wheat Production and Functional Traits, Models 7-8

	Model 7			Model 8		
	Parameter	SE	T-Ratio	Parameter	SE	T-Ratio
PRICE	-0.7479	0.0457	-16.356	-0.7935	0.0487	-16.29
A_S15	-6.0697	0.4194	-14.473	-7.9984	0.4319	-18.518
A_S14	-4.2601	0.2073	-20.547	-6.1802	0.2339	-26.426
A_S13	-6.1907	0.2973	-20.826	-8.0842	0.3175	-25.461
A_W13	-3.1986	0.3981	-8.034	-3.1442	0.3974	-7.912
S15xTRE1	-0.1253	0.0087	-14.444	-0.1145	0.0087	-13.192
S15xGDP1	0.0001	0.0000	13.214	0.0001	0.0000	12.92
S15xAFR1	-2.0114	0.2596	-7.749	-2.1199	0.2601	-8.15
S15xCSA1	1.418	0.1274	11.132	1.3418	0.1276	10.513
S15xEUR1	3.5003	0.1277	27.411	3.3642	0.1285	26.188
S15xFSU1	-32.813		0	-32.7698		0
S15xNAM1	-0.347	0.1994	-1.74	-0.3817	0.2003	-1.906
S15xOCE1	-30.047		0	-30.2297		0
S15xLF_1	0.1198	0.0092	13.01	0.1234	0.0093	13.338
S15xTRG1	0.0305	0.0011	28.201	0.0292	0.0011	27.305
S15xURB1	-0.0292	0.0027	-10.981	-0.0291	0.0027	-10.86
S15xWHT1	0	0.0000	-2.503	0	0.0000	-2.647
S14xTRE2	-0.0031	0.0047	-0.66	0.0026	0.0048	0.54
S14xGDP2	0	0.0000	19.301	0	0.0000	18.593
S14xAFR2	-1.6171	0.0913	-17.708	-1.7736	0.0932	-19.03
S14xCSA2	0.9842	0.0601	16.376	0.8992	0.0613	14.672
S14xEUR2	1.5216	0.1039	14.648	1.37	0.1051	13.032
S14xFSU2	-33.4531		0	-33.4253		0
S14xNAM2	-1.7739	0.0954	-18.604	-1.8338	0.0969	-18.93
S14xOCE2	2.6599	1.0278	2.588	2.473	1.0352	2.389
S14xLF_2	0.0852	0.0047	18.245	0.0894	0.0048	18.689
S14xTRG2	0.0167	0.0009	18.804	0.0153	0.0009	17.405
S14xURB2	-0.0011	0.0013	-0.859	-0.0008	0.0013	-0.622
S14xWHT2	0	0.0000	-9.573	0	0.0000	-9.618
S13xTRE3	-0.0216	0.0068	-3.159	-0.0209	0.0068	-3.076
S13xGDP3	0	0.0000	1.95	0	0.0000	1.848
S13xAFR3	-0.0268	0.0985	-0.272	-0.1655	0.1002	-1.651
S13xCSA3	1.0037	0.0910	11.026	0.9335	0.0919	10.155
S13xEUR3	1.3392	0.1619	8.273	1.2033	0.1625	7.405
S13xFSU3	-3.5532	1.0106	-3.516	-3.5845	1.0123	-3.541
S13xNAM3	0.3757	0.0986	3.81	0.3308	0.1003	3.299
S13xOCE3	1.5851	1.4178	1.118	1.4002	1.4230	0.984
S13xLF_3	0.1033	0.0064	16.148	0.1077	0.0065	16.579
S13xTRG3	0.0194	0.0011	17.603	0.0181	0.0011	16.382
S13xURB3	-0.0058	0.0021	-2.767	-0.0058	0.0021	-2.726
S13xWHT3	0	0.0000	-4.077	0	0.0000	-4.187
W13xTRE4	-0.0699	0.0080	-8.708	-0.0757	0.0083	-9.109
W13xGDP4	0.0001	0.0000	25.856	0.0001	0.0000	25.474
W13xAFR4	0.5801	0.1533	3.784	0.5497	0.1535	3.582
W13xCSA4	0.0798	0.1481	0.539	0.0547	0.1482	0.369
W13xEUR4	-0.9954	0.3204	-3.107	-0.9661	0.3205	-3.014
W13xFSU4	-0.4846	0.7320	-0.662	-0.4786	0.7296	-0.656
W13xNAM4	-0.4918	0.1504	-3.269	-0.5	0.1502	-3.33
W13xOCE4	2.7689	1.2306	2.25	2.8153	1.2305	2.288
W13xLF_4	-0.0168	0.0087	-1.928	-0.0146	0.0087	-1.683
W13xTRG4	0.022	0.0011	19.144	0.0206	0.0011	18.098
W13xURB4	0.0004	0.0035	0.114	0.0009	0.0033	0.275
W13xWHT4	0	0.0000	1.473	0	0.0000	1.261
WETGLUTE				0.3106	0.0125	24.866
EXTRATE				0.3638	0.0150	24.202
Log L	-19061			-18591.5		

Wheat functional characteristics were added in Model 8 (Table 8) and have a highly significant impact on purchase choices. Wet gluten and extraction rates were included as choice attributes reflecting functional characteristics of the underlying choice. These were introduced by allowing the effect to vary only through the variables (treated like price). The results indicate these effects are highly significant (Table 8). Domestic wheat production is significant and was found to also have an interaction effect with urbanization as shown in Model 9 (Table 9). Interpretation of these is critical and illustrated below.

The likelihood ratio index (McFadden 1974) was derived for each model where $LRI=1-lnL/LnL_0$ and L_o is the restricted likelihood and L is the optimized value. In addition, a specification test was conducted to determine whether Model 9 (Table 9) was superior to the other models using likelihood values. This allows a test of each model against others with a likelihood ratio test. Given we have the "unrestricted model" identified, and we report the LR statistic for each of the "restricted models" using this test. To do so, we derived LR-Test of the other specification = -2ln(L(Restricted)L(Unrestricted)). This statistic is chi-square with the number of restrictions as the degrees of freedom (Table 10).

The results were all statistically significant indicating that Model 9 is statistically superior to the others and, thus, we use Model 9 for our economic interpretation below. The overall level of fit, measured by McFadden's (1974) likelihood ratio index is .41 without intercepts and .24 measured with intercepts only.

Finally, we did introduce several variables that resulted in non-convergence. One of these was the level of wheat imports from Canada but the model was unable to converge. The reason for this is related to the fact that Canada exports to only a small subset of the total number of importers included in our data set. If we simplified our model drastically, we get convergence. However, to do so requires restrictions on the existing model which we did not feel would be justified.

Economic Interpretation (Marginal Effects and Elasticities)

The economic interpretation of these results uses marginal values and/or elasticities as appropriate figures derived from Model 9.

Price Impacts. Prices capture differences across choices as well as their variability over time. Generally, there has been variability in premiums for higher protein choices over the time period of the study. Both own and cross price elasticities were derived. The own price elasticity is the percent change in the purchase probability resulting from a percent change in price. The cross-price is the effect of a one percent change in the price of S-15 on the purchase probability of S-15 (-3.535) and on the probabilities of others (0.189).

Results are shown in Table 11. These are highly price elastic and the elasticity is generally greater for choices with higher protein levels and less for lower quality. In all cases, the impact is significant and very important. The implication is that increasing the supply of higher quality wheats would have a disproportionately large increase in demand, resulting in an increase in incomes to those growers selling that choice. The cross price elasticities suggest that change in prices of the alternative have relatively little impact on purchase probabilities for S-15, S-13, and W-13. However, purchase probabilities for S-14 and W-Ord are highly responsive to price changes of other choices.

Table 9. Urbanization Interaction with Wheat Production, Model 9

	Model 9		
	Parameter	SE	T-Ratio
PRICE	-0.7921	0.0494	-16.0240
A_S15	-6.6066	0.4424	-14.9330
A_S14	-4.9585	0.2358	-21.0330
A_S13	-5.3564	0.3179	-16.8500
A_W13	-3.5096	0.4492	-7.8120
S15xTRE1	-0.1173	0.0090	-13.0960
S15xGDP1	.49D-04	.49D-05	9.9860
S15xAFR1	-2.5027	0.2597	-9.6370
S15xCSA1	0.9490	0.1303	7.2850
S15xEUR1	2.0756	0.1415	14.6670
S15xFSU1	-40.3299	.21D+07	0.0000
S15xNAM1	-5.7002	0.4220	-13.5080
S15xOCE1	-30.0775	.10D+08	0.0000
S15xLF_1	0.0978	0.0095	10.2940
S15xTRG1	0.0285	0.0011	27.0580
S15xURB1	-0.0348	0.0027	-12.8740
S15xWHT1	-0.0002	.11D-04	-20.0620
S15xU_W1	.73D-05	.35D-06	20.8500
S14xTRE2	0.0139	0.0049	2.8170
S14xGDP2	.28D-04	.21D-05	12.9600
S14xAFR2	-2.1969	0.0940	-23.3610
S14xCSA2	0.5253	0.0616	8.5240
S14xEUR2	0.3357	0.1142	2.9390
S14xFSU2	-40.3799	.13D+07	0.0000
S14xNAM2	-4.8648	0.2119	-22.9550
S14xOCE2	2.5642	1.0357	2.4760
S14xLF_2	0.0643	0.0047	13.6070
S14xTRG2	0.0133	0.0009	15.6510
S14xURB2	-0.0043	0.0013	-3.2090
S14xWHT2	-0.0002	.82D-05	-24.1450
S14xU_W2	.60D-05	.26D-06	23.3550
S13xTRE3	0.0024	0.0071	0.3470
S13xGDP3	-.30D-04	.53D-05	-5.6680
S13xAFR3	-0.8847	0.0995	-8.8910
S13xCSA3	0.1570	0.0919	1.7090
S13xEUR3	-0.0219	0.1786	-0.1230
S13xFSU3	-11.8751	1.1021	-10.7750
S13xNAM3	-2.9336	0.1870	-15.6870
S13xOCE3	1.7202	1.4254	1.2070
S13xLF_3	0.0522	0.0064	8.0920
S13xTRG3	0.0151	0.0011	13.3350
S13xURB3	-0.0107	0.0021	-5.0180
S13xWHT3	-0.0002	.97D-05	-23.5860
S13xU_W3	.69D-05	.28D-06	24.7320
W13xTRE4	-0.0803	0.0085	-9.4900
W13xGDP4	.93D-04	.39D-05	23.8490
W13xAFR4	0.6102	0.1685	3.6200
W13xCSA4	0.1881	0.1595	1.1790
W13xEUR4	-1.3087	0.3253	-4.0230
W13xFSU4	-0.7615	0.8053	-0.9460
W13xNAM4	-0.1066	0.1961	-0.5430
W13xOCE4	2.7950	1.2308	2.2710
W13xLF_4	-0.0032	0.0094	-0.3350
W13xTRG4	0.0188	0.0011	16.8370
W13xURB4	0.0013	0.0035	0.3770
W13xWHT4	-.39D-05	.13D-04	-0.3060
W13xU_W4	.32D-06	.43D-06	0.7460
WETGLUTE	0.3369	0.0131	25.6250
EXTRATE	0.3920	0.0158	24.7790
Log L	-17805.4		

Table 10. Specification Test for Model 9 versus Models 1-8

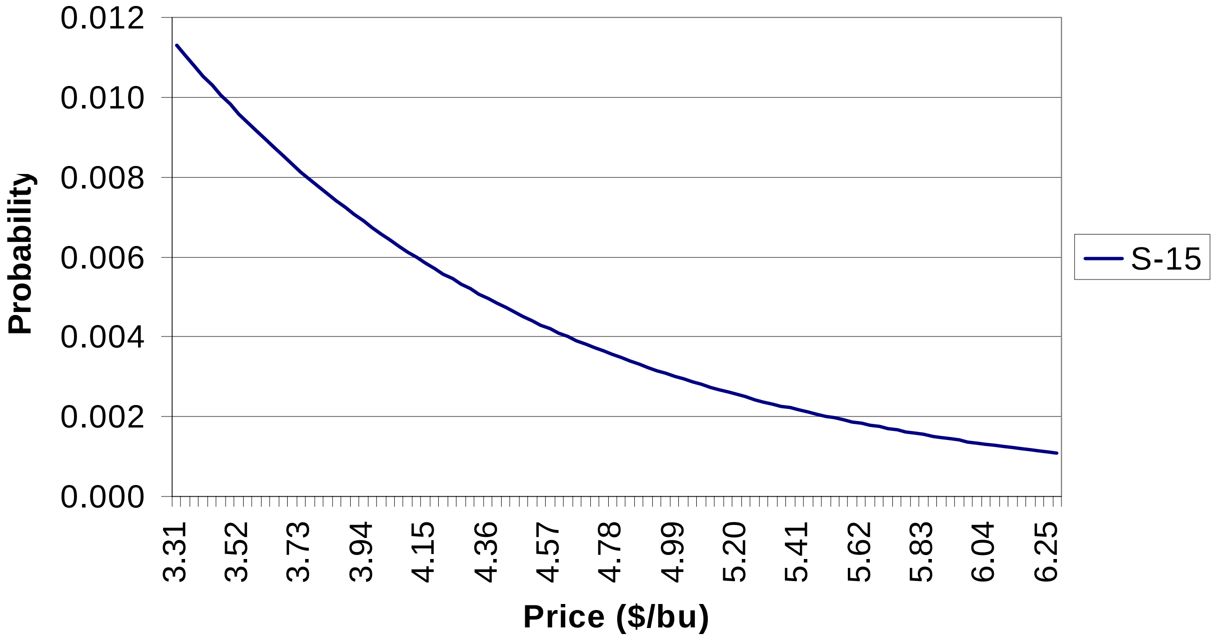
Model	Restricted Model Parameters	Log Likelihood	Chi Statistic	DF	Probability
1	4	-28572	21535	55	0.0000
2	8	-28491	21373	51	0.0000
3	9	-28316	21022	50	0.0000
4	13	-24356	13102	46	0.0000
5	37	-22336	9061	22	0.0000
6	49	-19576	3542	10	0.0000
7	53	-19061	2512	6	0.0000
8	55	-18592	1572	4	0.0000
9	59	-17805			

* Model comparisons assume Model 9 is Restricted Model and Degrees of Freedom is the difference in parameter estimates for the Unrestricted and Restricted Models.
Chi Statistic = -2* (Unrestricted log likelihood-Restricted log likelihood).

Table 11. Price Elasticities: Own and Cross

Choice	Own Price	Cross-Price
S-15	-3.529	0.189
S-14	-2.309	1.093
S-13	-3.021	0.247
W-13	-3.057	0.184
W-Ord	-1.556	1.497

These effects are reflected in a series of figures representative of demand functions for each choice (Figures 6 to 11). These are the impact of own price on the probabilities of purchasing. In all cases, an inverse relationship is observed, meaning that an increase in price, results in a lower purchase probability. However, there are radical differences across the choices. The figures also show the relationship between the purchase probability for each alternative choice as the price for a specified class increases. These results are fairly interesting. It shows that as the price of S-15 changes, it has near inconsequential impact on purchase probabilities of other classes. This contrasts sharply with both W-Ord and S-14. Increases in either of these have radical differences in purchase probabilities of substitutes. For increases in the price of W-Ord, there are sharp increases in S-14, but lesser of the other choices. For increases in the price of S-14, the purchase probability for W-Ord increases. It is interesting that there is a greater increase for S-14 than for the others. These suggest that S-14 and W-Ord seem to have most of the substitution effects. If prices of S-14 increase, demanders will be moving toward more W-Ord (and vice versa). Thus, to the extent that prices of one are increasing more than the other, it points toward growth.



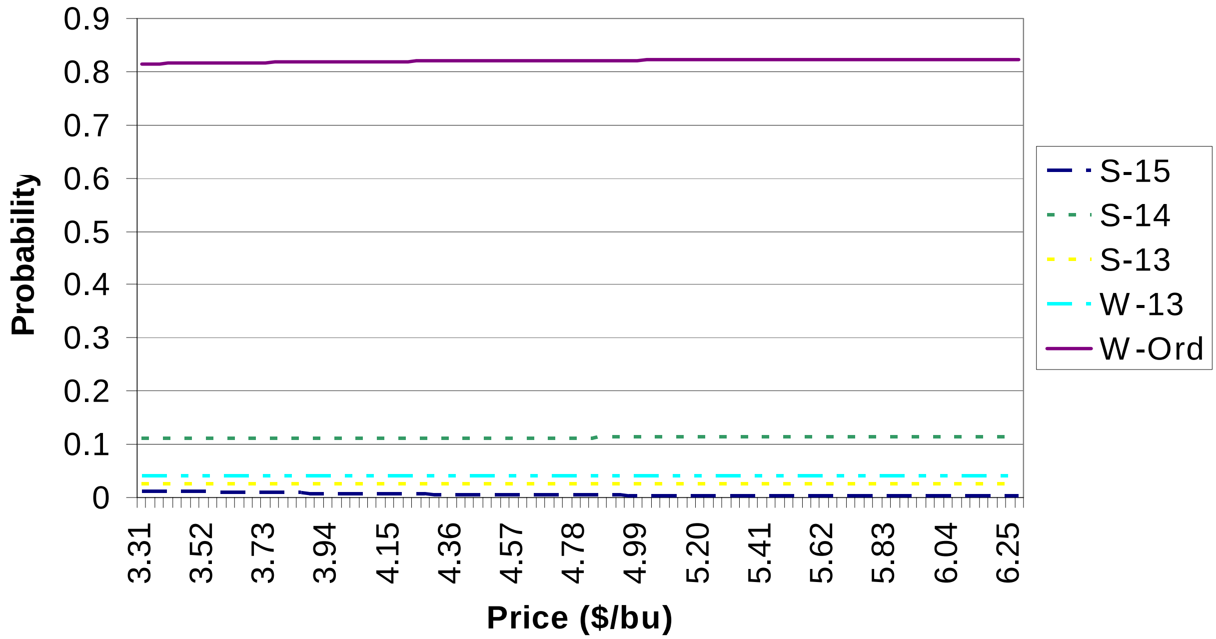
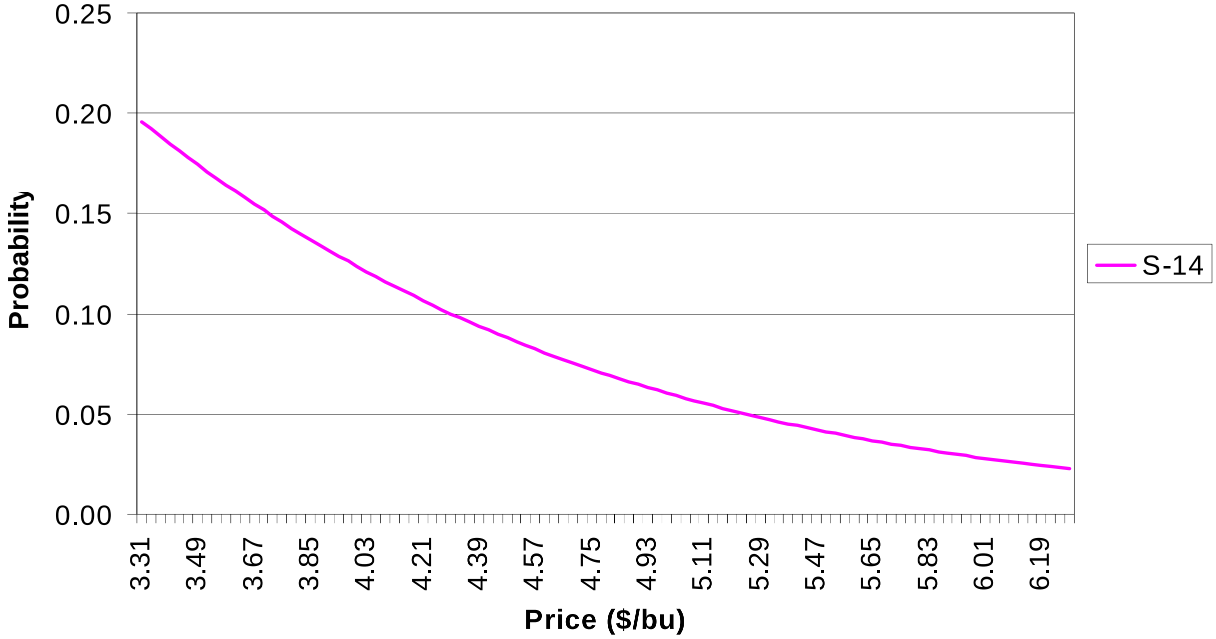


Figure 6. Effect of Price on Probability of S-15 Being Chosen



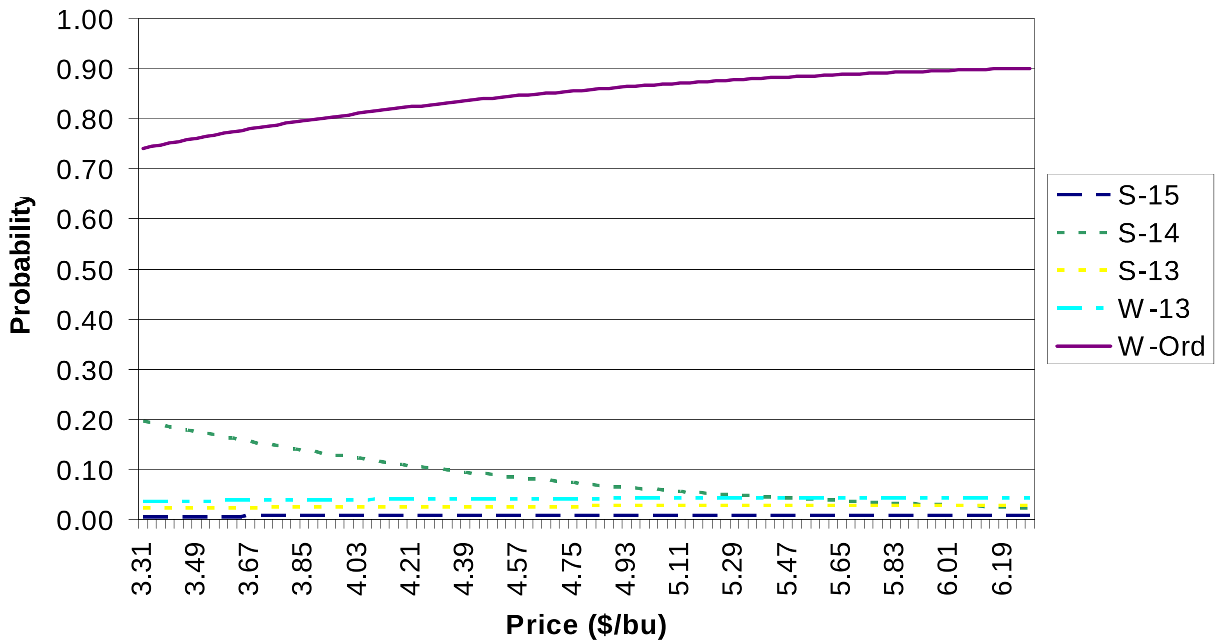
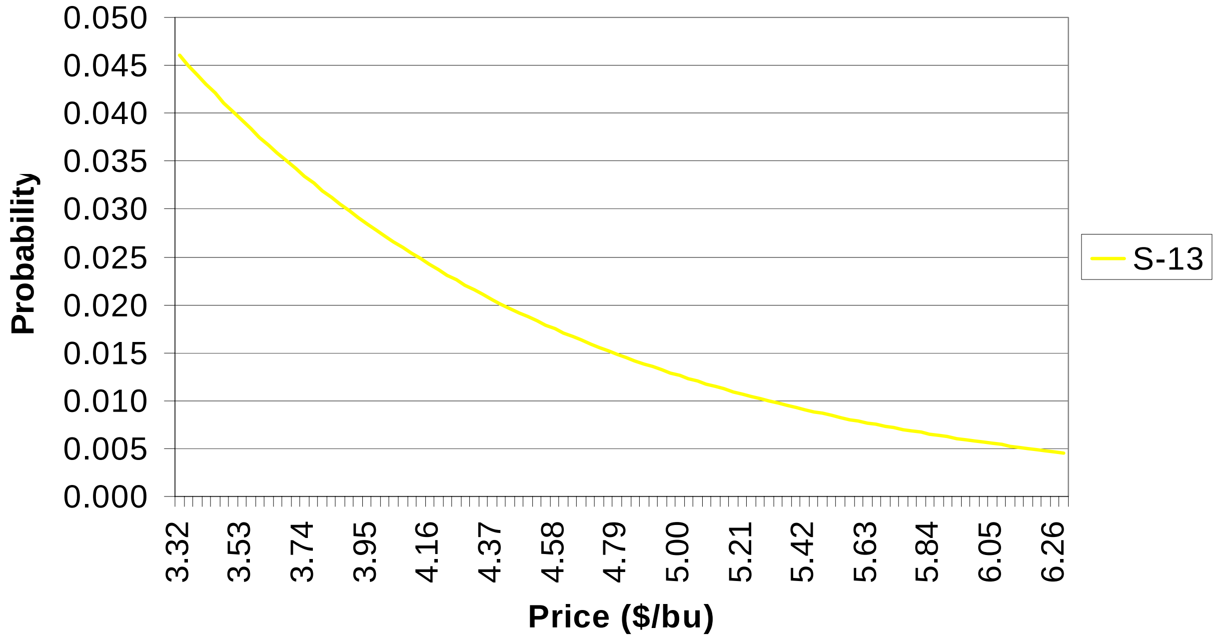


Figure 7. Effect of Price on Probability of S-14 Being Chosen



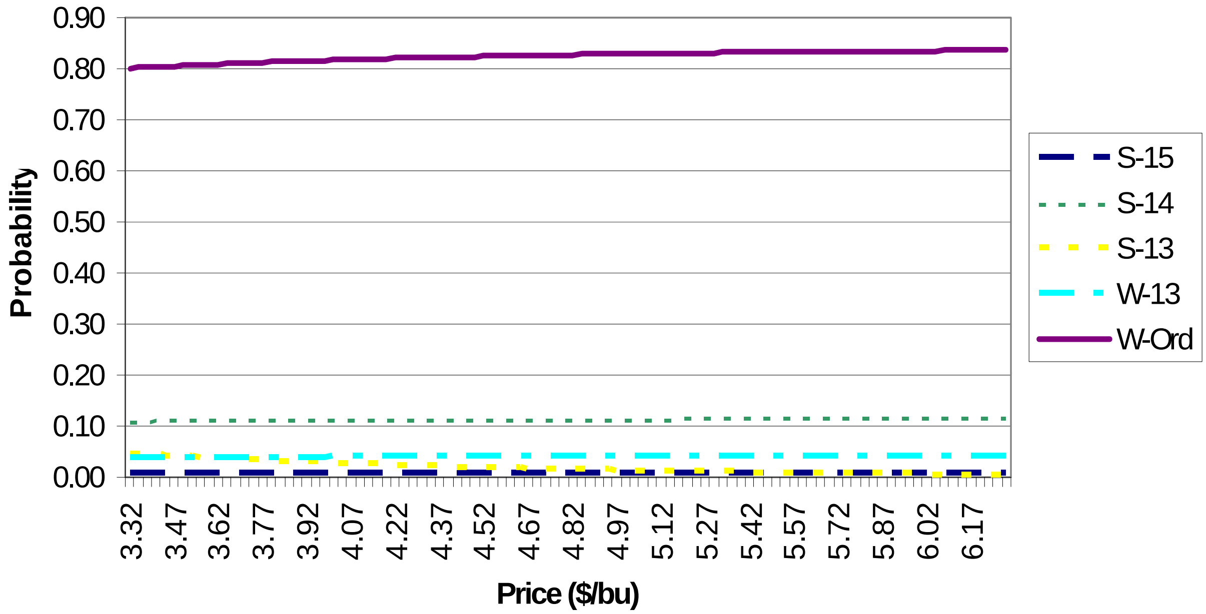
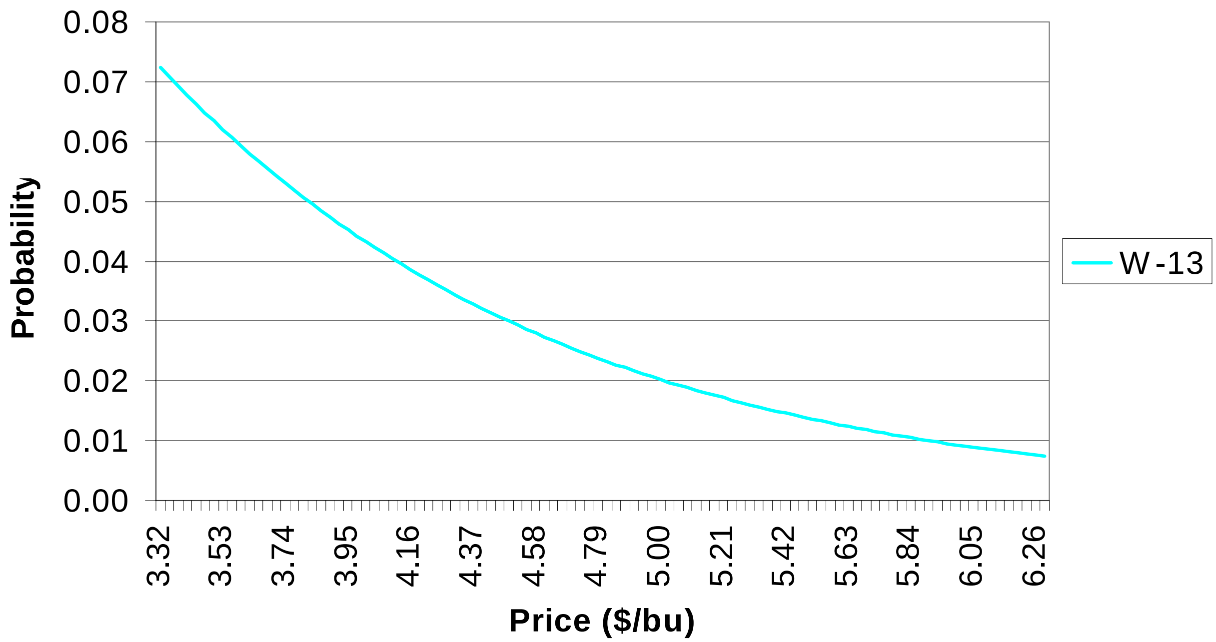


Figure 8. Effect of Price on the Probability of S-13 Being Chosen



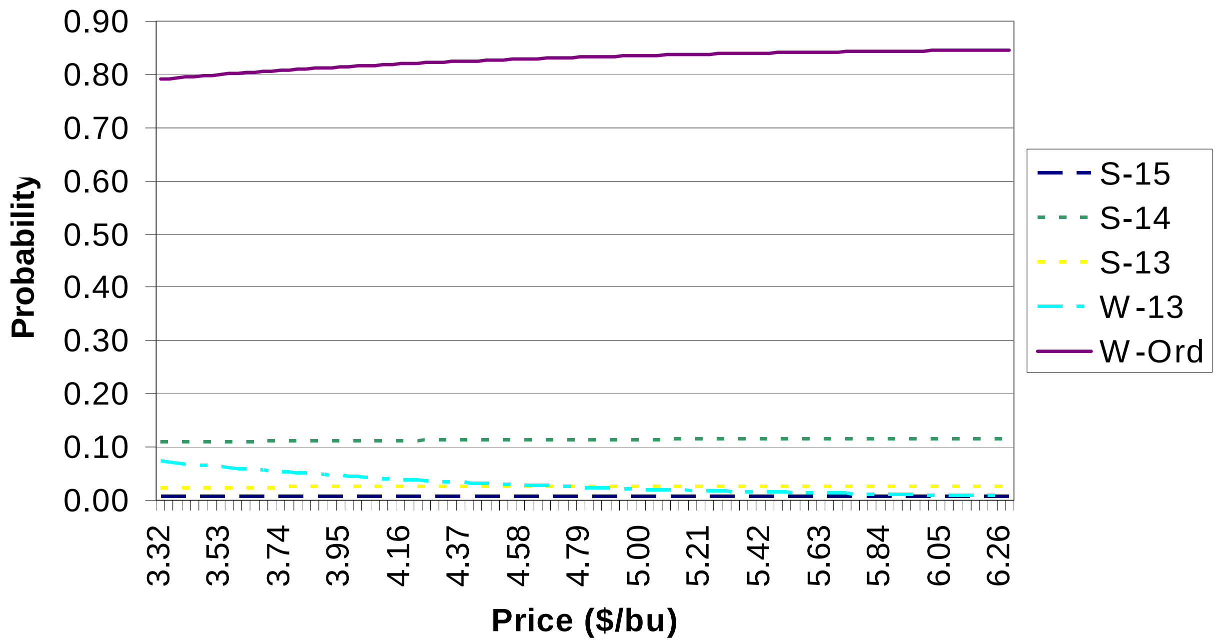


Figure 9. Effect of Price on the Probability of W-13 Being Chosen

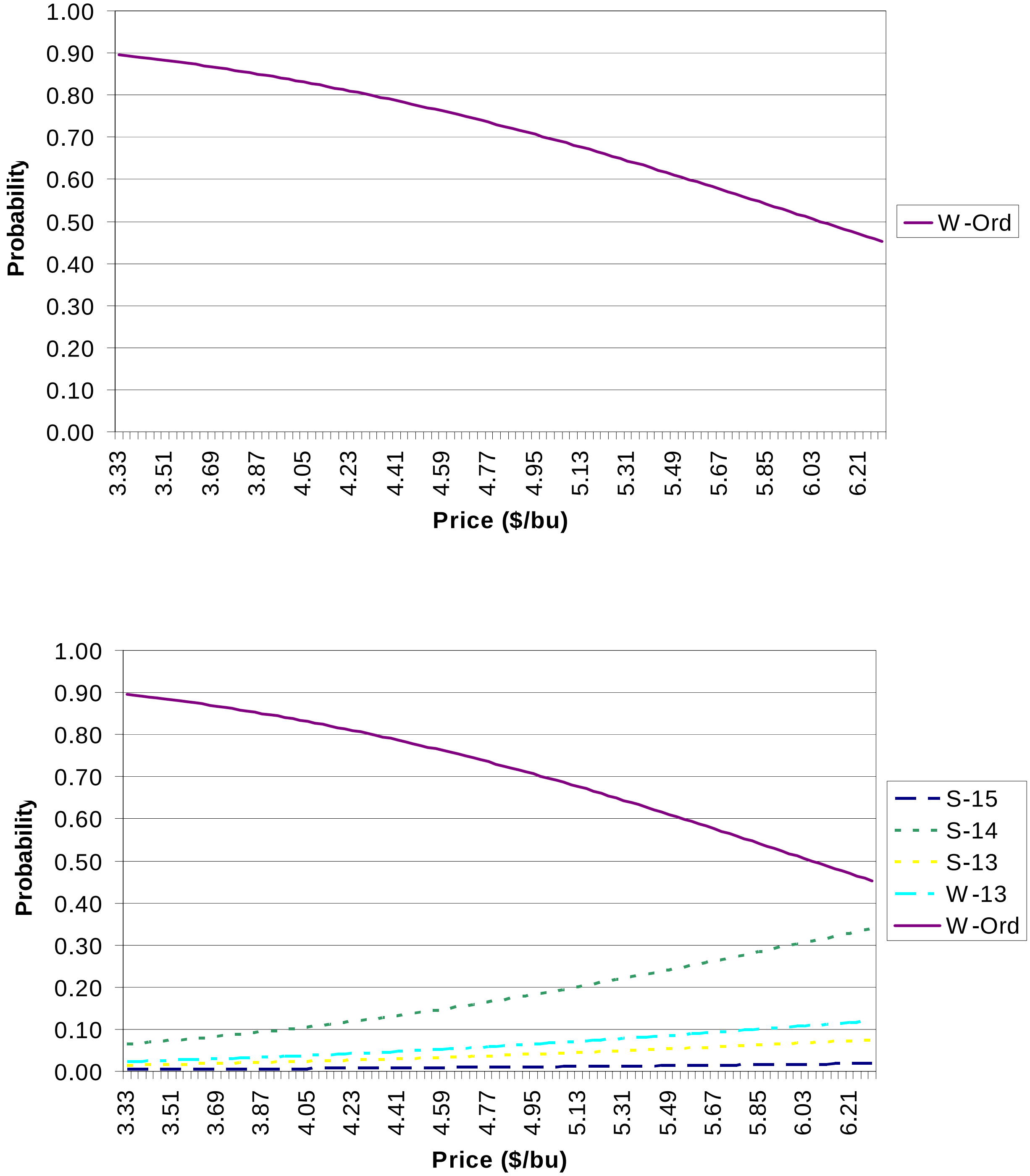


Figure 10. Effect of Price on Probability of W-Ord Being Chosen

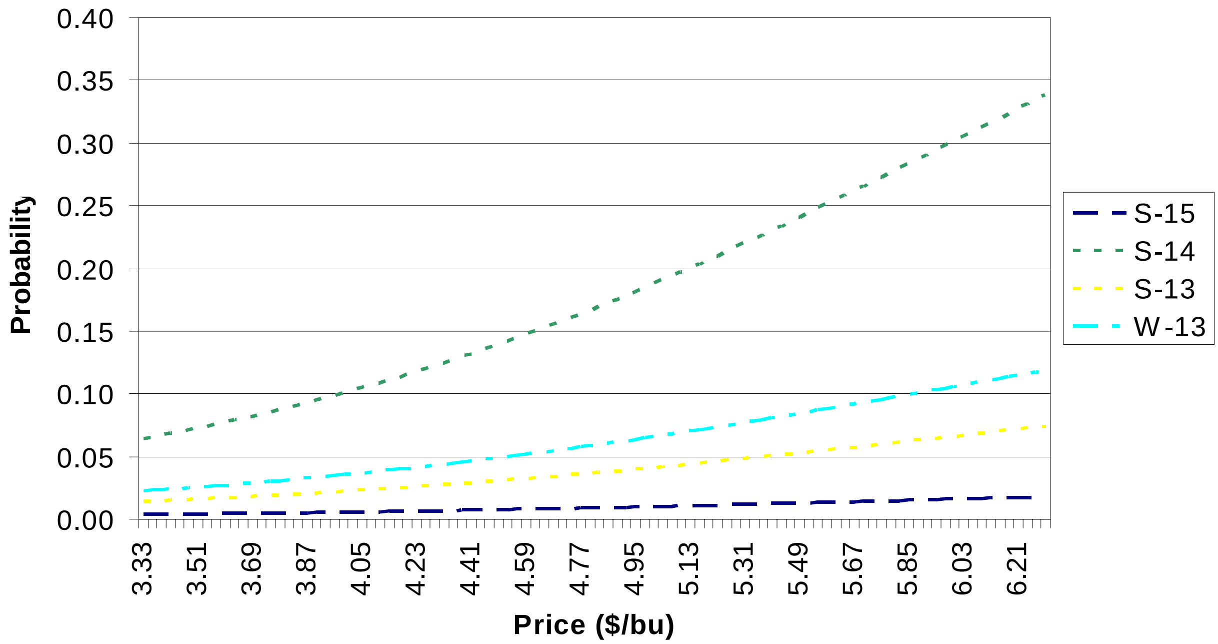


Figure 11. Probability of W-13, S-13, S-14, and S-15 Against Probability of W-Ord, by Price

We also derived the purchase probability for S-14 and W-Ord for each region (Figures 12 and 13). The results show that for S-14, the greatest purchase probability is for Oceania, followed by Central and South America, Europe, and Asia. The others have near-nil purchase probabilities at all prices. These contrast with W-Ord. In this case, the strongest demand is at FSU and NAM, followed by Africa and then Asia, Europe, and CSAM. These clearly show there are idiosyncratic demands for protein and class across regions.

Macroeconomic and Demographic Attributes. The macroeconomic and demographic variables retained in the final model include the level of traded goods, the percent of females in the work force, income, urbanization, and wheat production. Impacts of each are discussed. Elasticities for each are in Table 12.

The level of traded goods is a measure of the amount of trade in all goods. These results indicate that the level of trade is positively related to each choice. Simply, an increase in trade has the impact of increasing the purchase probability of W-13, S-13, S-14, and S-15 at the cost of W-Ord. Countries with greater trade would have greater purchase probabilities for these choices. Of particular interest is that there appears to be greater elasticities for choices that are higher protein within each class.

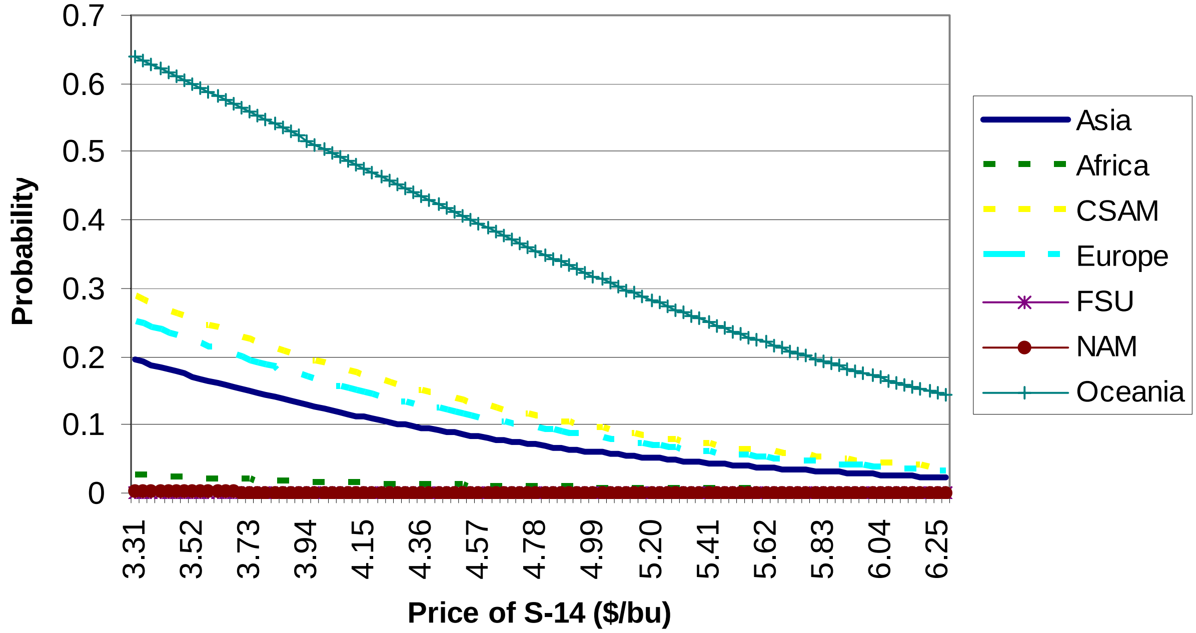


Figure 12. Demand Schedule (Probability against Price) for S-14, by Region

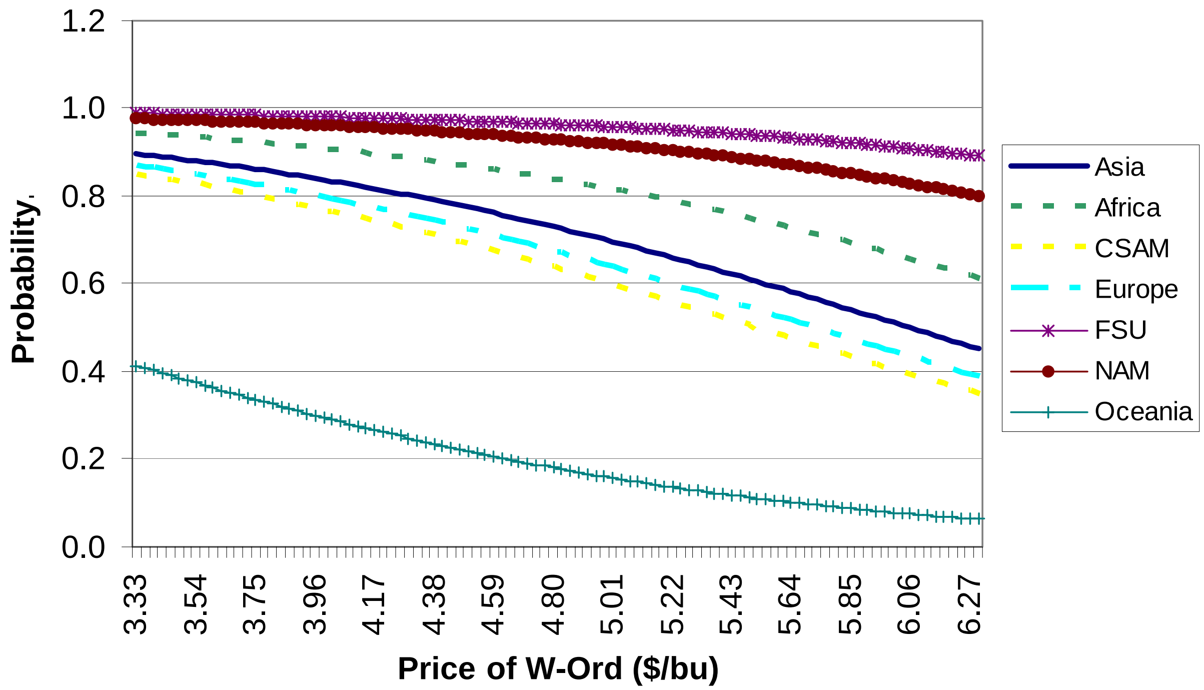


Figure 13. Demand Schedule (Probability against Price) for W-Ord, by Region

Table 12. Elasticities for Urbanization – Domestic Wheat Production Interaction Model (Model 9)

	Price	Wet Gluten	Extraction Rate	Trend	GDPPC
S-15	-3.529	11.114	25.864	-0.005	0.469
S-14	-2.309	7.918	18.412	0.002	0.157
S-13	-3.021	10.841	25.226	0.000	-2.940
W-13	-3.057	8.575	26.352	-0.004	0.830
W-Ord	-1.556	4.604	14.229		
	LA_Female	**TR Goods**	**Urban**	**WhtProd**	**U_WhtPro**
S-15	3.398	1.308	-2.075	-0.997	1.378
S-14	1.573	0.438	-0.178	-0.777	0.966
S-13	1.768	0.690	-0.628	-0.996	1.233
W-13	-0.110	0.885	0.078	-0.018	0.064
W-Ord					

* Elasticities for Model 9 (Table 9). Values could not be derived for W-Ord for some of the variables.

Variability in income has an important impact on import choice. Generally, these are positive and relatively inelastic with the exception of S-13. Thus, countries with greater incomes have greater purchase probabilities for S-15, S-14, and W-13 relative to W-Ord. However, they would have a lesser purchase probability for S-13. This suggests that low income countries would have a greater tendency to purchase S-13, whereas higher income countries would have a greater tendency to purchase higher protein choices in HRS and HRW wheat.

Two demographic variables were included. Female participation and urbanization were included as a measure of the demand for convenience. Greater female participation in the workforce would tend to have greater demand for products that would be more convenient, and for ingredients necessary to produce these products (e.g., meals away from home, hamburgers, fast food, pizza, etc.). These results indicate this is a very significant effect. The elasticities for each of the HRS wheat choices are all positive and relatively large. In addition, the elasticities for S-15 are nearly double those for the lower protein HRS wheats. These suggest that countries with a greater female workforce tend to buy a greater proportion of higher protein HRS wheats than others.

The other demographic variable is urbanization which measures the share of population living in urban centers. There has been a growing trend over time of more urbanized countries and some regions have greater urbanization than others. By itself, greater urbanization has the impact of reducing purchase probabilities of the HRS wheat choices. However, we found this to be highly dependent on the level of domestic wheat production. As it turns out, this impact has an interesting effect on choice probabilities. The effect of each wheat production and urbanization is negative when evaluated individually. However, there is a positive interaction effect. Thus, the impact of urbanization depends on the effect level of wheat production, and these vary substantially across the choices.

These relationships are shown in Figures 14 and 15. As domestic wheat production increases, the purchase probability for S-15 increases. This is likely due to the fact that in many countries, local wheat production is generally of lower functional quality, which has the impact of shifting the choice probability for imports to higher proteins for blending purposes. For S-14 and S-13, the effect of wheat production is initially positive and then becomes negative. This suggests that for these choices, for countries with lower levels of wheat production, the effect is positive; but for countries with larger levels of wheat production, the effect turns negative. For both W-13 and W-Ord, the effect is largely negative, but highly non-linear. For these choices, increases in local wheat production have the impact of reducing the imports of this class. This is likely due to the demand for blending. If and as local production is generally of lower quality and protein, there is a lesser need to supplement imports with like quality wheat.

These results provide much better clarity on the role of urbanization versus previous suggestions. Increased urbanization and higher incomes were thought to cause lower wheat consumption in China (Courtmanche 2004; Lohmar 2004, p. 5). These studies refer specifically to China and suggest these recent trends ("income growth, rural commercialization, and urbanization are effecting a shift away from the consumption of wheat as food in China"). These are suggestive of the issue, but contrast with our results which focus on imports, across a broad range of countries, and estimate purchase probabilities. Nevertheless, these results would suggest that as urbanization and wheat production change, the share of different quality and protein of imports would change as well.

<u>Functional Characteristics (Wet Gluten and Extraction)</u>. Wet gluten content and extraction rates are two important quality characteristics in these wheat classes and values for these were included as choice attributes. These effects were highly significant. To evaluate their effect we derived both the elasticities (Table 12) and the marginal effects of each (Table 13). These results indicate the improvement in both have a positive impact on the purchase probability for that choice. And, as shown in the elasticities, it is important that the impact is greater for higher protein choices, and for HRS vs. HRW wheat.

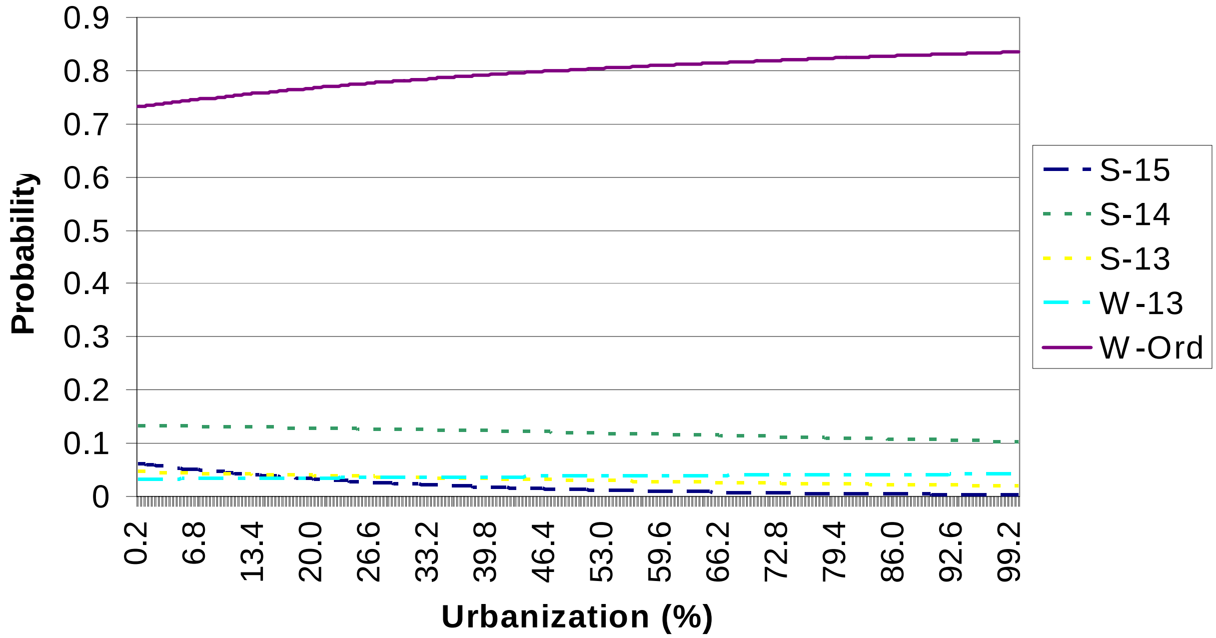


Figure 14. Effect of Urbanization on Purchase Probabilities

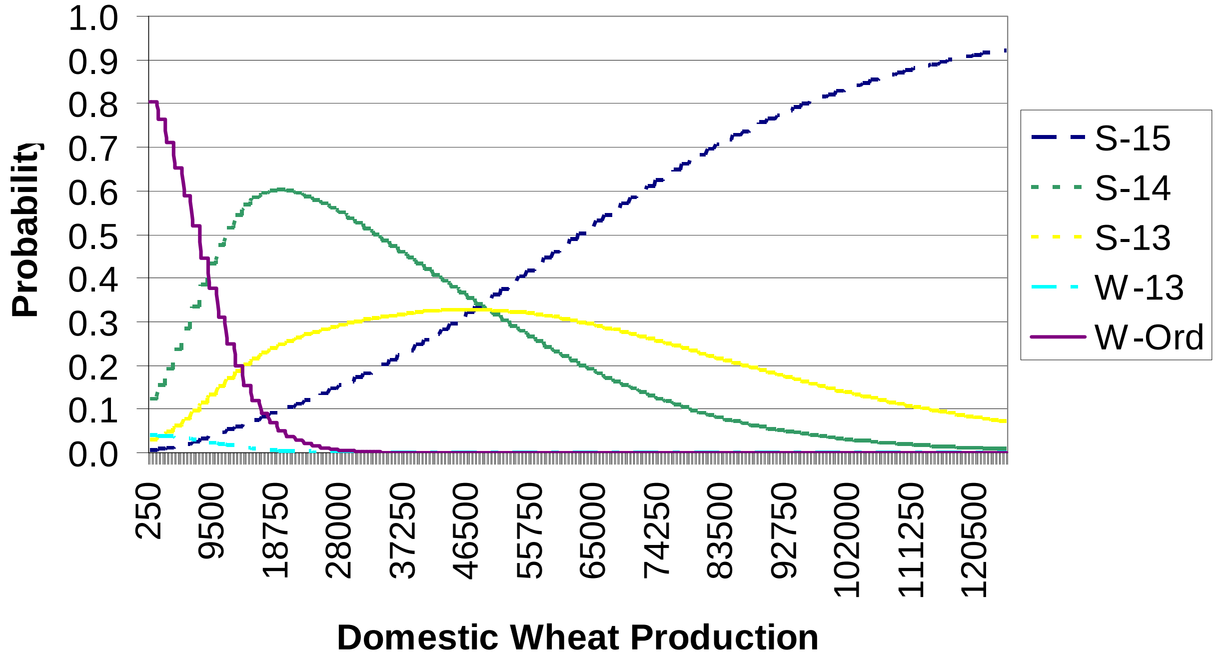


Figure 15. Effect of Wheat Production and Median Urbanization on Purchase Probabilities

Table 13. Marginal Effects of Wet Gluten and Extraction Rates

	S-15	S-14	S-13	W-13	W-Ord
			Wet Gluten		
S-15	0.01	-0.01	-0.00	-0.00	-0.00
S-14	-0.01	0.06	-0.01	-0.01	-0.04
S-13	-0.00	-0.00	0.02	-0.00	-0.01
W-13	-0.00	-0.01	-0.00	0.02	-0.01
W-Ord	-0.00	-0.04	-0.01	-0.01	0.06
			Extraction Rate		
S-15	0.02	-0.01	-0.00	-0.00	-0.00
S-14	-0.01	0.07	-0.01	-0.01	-0.04
S-13	-0.00	-0.01	0.03	-0.00	-0.01
W-13	-0.00	-0.01	-0.00	0.02	-0.01
W-Ord	-0.00	-0.04	-0.01	-0.01	0.07

The marginal effect is the impact of a one-unit change in the characteristic on the probability of purchasing a designated choice. Marginal effects were also derived for the other choices. The results indicate the marginal effects are greatest for S-14 and W-Ord for both wet gluten and extraction. These mean that a one-unit increase in wet gluten results in a .06 increase in purchase probability of S-14, and a decline in the purchase probability for each of the other choices. That for W-Ord declines the most at -.04. It is interesting that these effects are generally greater for S-14 and W-Ord, the two dominant choices in world trade. While these numbers appear quite small, e.g., a one-unit change in wet gluten and extraction yield a -.04 to .07 change in probability, the results in elasticity form are much larger (Table 12). Here a 1% change in wet gluten has a 4 to 10% change in the probabilities, while a 1% change in extraction has a 13 to 25% change in probabilities.

These results have important implications for breeders. They indicate that improvements in quality, measured here by wet gluten content and extraction, results in an increase in purchase probabilities or market shares. This effect already considers the impact of prices, as well as other macro and demographic variables. Thus, quality improvement is reflected not only in an increase in price, but also an increase in market shares for that choice. This is fairly important and provides greater insight on this issue than reflected in most other studies on hedonic price functions. In terms of the hedonic function, these are product characteristics, and results strongly suggest they matter to the demander.

In our model, the importer utility function depends on attributes of a product, which is the same as in the hedonic models. In this literature, consumer utility functions depend on product attributes. The utility and offer functions are solved for an equilibrium price function and typically regressed on product attributes. In our model, we estimate indirect utility functions. We find that product attributes are extremely important. The results can be used to generate willingness to pay measures for product attributes which we leave as an extension.

Regional Impacts. Interpretation of the regional coefficients is the change in the log odds of choosing class/protein relative to W-Ord. The effect of regions was evaluated by fitting the probability function for each alternative with and without the dummy for each region at median values (following Greene 2003, p. 668). The marginal effect of a region is the difference of the two probabilities. Interpretation of each entry in Table 14 is the difference in the probabilities (at median values) of demanding a specific grade (S-15) between the region listed (e.g., Africa) and the base region (Asia).

Table 14. Marginal Effects of Regional Differences (measured relative to Asia)

	Africa	CSAM	Europe	FSU	NAM	Oceania
S-15	-0.53	0.79	3.81	-0.58	-0.58	-0.58
S-14	-9.79	6.01	0.04	-11.14	-11.04	36.45
S-13	-1.34	0.16	-0.18	-2.44	-2.29	2.04
W-13	3.96	0.36	-2.90	-1.73	0.19	17.09
W-Ord	7.70	-7.34	-4.35	15.89	13.72	-55.00

The value in the cell is the change in the probability with and without the dummy. For example, suppose the estimated probability of S-14 for Asia is 50%, the value of -9.79 for Africa means the estimated probability for Africa is 40.21%.

The results can be interpreted about a region's idiosyncratic preference relative to those in Asia. As example, Africa has negative preference for S-15, S-14, and S-13 but a very strong preference for W-13 and W-Ord. The latter are about twice as great. Compared with Asia at the same reference values, Africa will import .5 percentage points less of S-15, 9.8 percentage points less of S-14, 1.3 percentage points less of S-13, 4 percentage points more of W-13, and 7.7 percentage points more of W-Ord.

The results are nearly just the opposite in Europe. In that case, Europe has a very strong preference for S-14 and S-15, but a weaker preference for S-13, W-13, and W-Ord. Compared to Asia and holding everything else constant, Europe will import nearly 4 percentage points more of S-15 and S-14, but substantially less of the other classes.

Finally, there are some other peculiarities worth noting. Central and South Amercia (CSAM) have strong preferences for all spring wheats, but not lower protein winters. NAM (this region includes: Canada, United States, and Mexico; however, since we are looking at U.S. exports and Canada does not import significant quantities, this largely reflects Mexican imports) has stronger preferences for W-Ord. And, Oceania has extremely strong preferences for S-14 and W-13, but extremely negative (weak) preferences for W-Ord.

Trend. The trend coefficients are significant, and their values vary from Model 2 to Model 9. The signs are comparable between these models, but the magnitude of the impact is far greater in Model 9 (i.e., after considering the other effects). To illustrate these effects, we derived $\partial Prb/\partial t$ where Prb is the probability and t is time, for each choice. These were derived for what we refer to as the unconditional model (Model 2) and the conditional model (Model 9). The value of W-Ord was inferred from the summation of the values across choices and equated to 0. The results are shown in Table 15. The values are the change in the probability for each unit of time, in this case 1 year, and can be interpreted as the per unit change in market share. Results show that in the unconditional model, there are decreases in market shares for S-15, S-13, and W-13. That for S-14 is positive. In contrast, after holding constant the impacts of all of the RHS variables, the sign of the coefficients are unchanged (with the exception of S-13), but the magnitude of the impact is greater. Thus, assuming all else constant, there are declining trends for S-15 and W-13 and increasing trends for S-14 and W-Ord.

Table 15. Trend Effects on Purchase Probabilities

	Unconditional Trends	Conditional Trends
S-15	-0.223	-4.870
S-14	0.397	0.243
S-13	-0.054	0.016
W-13	-0.194	-0.386
W-Ord	0.074	4.997

Summary and Implications

Protein in wheat is a quality characteristic that is measured in the marketing system and is an important specification in most hard wheat contracts. It has a premium which is important to all participants in the marketing system, but it is highly variable and in recent years has been quite high. Some buyers buy only one protein level, others buy multiple levels and/or classes, and these choices vary through time. The purpose of this report was to analyze the cross-sectional and time series demand for protein choices in the hard wheat market and to evaluate factors that impact these choices.

We developed a choice-based model of wheat purchasing and estimated it using a hybrid model, incorporating multinomial and conditional relationships. We used a detailed set of data on export shipments across countries and through time which included whether the buyer specified protein and, if so, which class and protein level did thy purchase. We tested for different specifications and analyzed the impacts of trend and regional geography, as well as prices and macroeconomic and demographic factors on purchase choices. In addition, we included the impact of functional wheat characteristics on purchase choice.

The results indicate that there have been increasing trends (in the unconditional model) overtime in S-14 and W-Ord but decreases in the other choices. Prices are highly elastic and higher for higher protein levels. Amongst the macroeconomic and demographic effects, urbanization and females in the work force had important impacts, generally favoring higher protein wheats and reflecting the demands for convenience. Urbanization and wheat production have an interesting impact on purchase probabilities. In particular, for the higher protein classes, there was a positive relationship to wheat production. For S-14 and S-13, this peaks as wheat production increases, and then declines. In contrast, for each of the HRW wheat choices, increases in wheat production reduced purchase probabilities. Taken together these suggest that importers' choice of quality are highly impacted by the level of their local wheat production. For countries with higher production, there is a tendency to shift to higher protein imports, suggesting the need for blending purposes. For countries with lower production, there is a greater tendency to reduce their purchases of the lower protein HRW wheats from the United States. Thus, these wheats are more substitutes for local production. Finally, functional characteristics have an important impact on purchase probabilities. In particular, increases in either extraction rates or wet gluten had a significant impact on purchase probabilities.

There are three sets of implications from these results. First, the results provide a better understanding of the role of quality and wheat protein on importers' choice. As such, they should provide a better understanding of the role of these classes of wheat in international trade and competition. Second, these clearly suggest there are a multitude of segments in the international wheat market. In this case, they are segmented by class and protein choice. Incomes and geography, as well as demographics including women in the work force and urbanization, all impact a country's purchase choices. These help explain existence of segments and have implications for market promotion. Specifically, the results should be able to help target market promotion strategies coinciding with these variables. The results clearly indicate that HRS wheat and higher proteins are preferred in some regions, but not others, and differently for HRW wheat. Finally, the results have important implications for breeders. In particular, they clearly indicate that improvements in functional characteristics, beyond the protein level and associated premiums, increases purchase probabilities and market shares.

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Appendix Tables

Table A1. Correlation of Protein and Selected Quality Characteristics (HRW Export Cargo Survey Data, 1985-2004)

	Protein	Fall Number	Wet Gluten	Absorp.	Peak Time	Tol.	Loaf Vol	Extract Rate	Flour Ash
Protein	1		0.71		0.38				
Fall No		1							0.56
Wet Gluten			1	0.36	0.42		0.35		0.45
Absorp				1		-0.54			
Peak Time					1	0.76			0.40
Tol.						1			
Loaf Vol.							1		0.68
Extract. Rate								1	
Flour Ash									1

Table A2. Correlation of Protein and Selected Quality Characteristics (HRS Export Cargo Survey Data, 1985-2003)

	Protein	Fall Number	Wet Gluten	Absorp.	Peak Time	Tol.	Loaf Vol	Extract Rate	Flour Ash
Protein	1	0.47	0.41		0.59	0.61			
Fall No		1	0.44		0.50	0.52	0.27		
Wet Gluten			1			0.29		-0.34	
Absorp				1	0.36	0.29			
Peak Time					1	0.84			
Tol.						1			
Loaf Vol.							1	0.29	0.42
Extract. Rate								1	0.42
Flour Ash									1