

# **The Price Responsiveness of U.S. Wheat Export Demand by Class**

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## **The Price Responsiveness of U.S. Wheat Export Demand by Class**

The objective of this research is to analyze the factors affecting the price responsiveness of disaggregated classes of U.S. wheat exports. Factors examined in this study that are likely to influence U.S. exports on a class-by-class basis include wheat prices – own price and cross price effects from wheat classes and competitive substitutes such as feedgrains; supply-demand balances by wheat class for major export sellers & import buyers; ocean freight costs for U.S. grain exports; and exchange rates for the U.S. dollar & other currencies. Using public data from domestic and international sources, single equation models of U.S. wheat export demand were developed, with one group of U.S. wheat export competitor models by wheat class, and a second group of U.S. wheat export share models by class. Results indicate that both own price and cross price responsiveness of U.S. exports was found in hard red winter and hard red spring wheat class exports. Soft white wheat and soft red winter wheat exports were unresponsive to own or cross price effects, but instead responded to changes in world wheat and corn supply-demand balances. Ocean freight rates, U.S. currency exchange rates and quarterly period seasonal factors also at times influenced U.S. wheat exports in these results. Additional factors likely to influence class-by-class U.S. wheat exports that are not explicitly examined in this study include the proportion of food versus feed quality wheat by class as is most common in individual exporting and importing countries, and protein and quality factors for U.S. wheat by class. Future applied research efforts will need to account for these factors.

*Key words: export demand, wheat, wheat classes, corn, agricultural prices.*

### **Introduction**

Exports are the key component of United States' wheat demand that determines prices. While U.S. domestic food demand for wheat is also substantial in quantity, it has closely followed population trends with little variability or uncertainty, and has not impacted wheat market prices in the same manner that variations in U.S. wheat exports have. Feed use of wheat can vary substantially on an annual basis, but has been typically small in quantity relative to either exports or domestic food use. Wheat seed use is only a small proportion of annual U.S. wheat usage. All told, wheat export demand has been the primary determinant of U.S. wheat prices since the 2000/01 marketing year, with other categories of usage affecting price variations to a much lesser degree.

From the 2000/01 through 2010/11 marketing years, U.S. wheat exports have varied substantially on an annual basis, averaging 1.041 billion bushels (bb) with a range of 850 million bushels (mb) to 1.289 bb, and a standard deviation of 139 mb. This variability in aggregate U.S. wheat exports may tend to obscure the annual variation that has occurred in exports for the various U.S. wheat classes. On a proportional basis, for the 2010/11 marketing year, hard red winter (HRW) wheat accounted for 54.5% of U.S. wheat exports (616 mb or 1.131 bb total), followed by hard red spring (HRS) wheat (339 mb or 30.0%), soft red winter (SRW) wheat (109 mb or 9.6%), durum wheat (96 mb or 8.5%) and hard (HW) and soft white (SW) wheat (95 mb or 8.4%).

Although some common factors affect U.S. wheat exports across these classes (exchange rates, world economic trends, overall aggregate world wheat supply-demand balances), a number of factors that impact export demand for these various U.S. wheat classes differ markedly. This is because of both variation in the characteristics of the alternative types of U.S. wheat and heterogeneous preferences across wheat importing countries.

### *U.S. Wheat Classes*

Hard red winter wheat (HRWW) is a hard, brownish, mellow high-protein wheat used for bread, hard baked goods and as an adjunct in other flours to increase protein in pastry flour for pie crusts. Hard red winter wheat made up 55% (616 million bushels or mb) of U.S. wheat exports in the 2010/11 marketing year (i.e., MY 2010/11, June 1, 2010 through May 31, 2011). Argentina is a major U.S. HRWW export competitor.

Hard red spring wheat (HRSW) is a hard, brownish, high-protein wheat used for bread and hard baked goods. Hard red spring wheat made up 30% (339 mb) of U.S. wheat exports in MY 2010/11. Canada is a major U.S. HRSW export competitor.

Hard white wheat (HWW) is a hard, light-colored, opaque, chalky, medium-protein wheat planted in dry, temperate areas, whereas soft white wheat (SWW) is a soft, light-colored, very low protein wheat grown in moist temperate areas. Together, hard and soft white wheat (WW) made up 8% (95 mb) of U.S. wheat exports in MY 2010/11. Australia is a major U.S. WW export competitor.

Soft red winter wheat (SRWW) is a high yielding, soft, low-protein wheat used for flat breads, cakes, pie crusts, pastries, biscuits, muffins and crackers. Soft red winter wheat made up 10% (109 mb) of U.S. wheat exports in MY 2010/11. The European Union is a major U.S. SRWW export competitor is, as well as are other countries.

Durum wheat is a very hard, translucent, light-colored grain used to make semolina flour for pasta and bulghur. Durum wheat made up 3% (43 mb) of U.S. wheat exports in MY 2010/11. Canada is a major U.S. durum wheat export competitor.

### *Previous Research*

Previous research has focused on alternative types of class-by-class market share and price comparisons, and has wrestled with an inherent lack of international class-specific wheat export data. Wilson and Gallagher (1990) examined factors affecting World market shares by wheat class, along with price responsiveness & substitutability. Konandreas, Bushnell and Green (1978) focused on aggregated world wheat importing countries by region rather than by particular wheat classes in their examination of how relative U.S. wheat export prices impact U.S. export demand. Relative wheat prices were defined as aggregate U.S. wheat prices vs prices in importing countries. Cross price effects of substitute commodities were also included.

Haniotis, Baffes and Ames (1988) used a dynamic system of export supply and demand equations to examine the demand and supply of U.S. wheat, corn and soybean exports. This

study was particularly useful in the identification of data sources and in its description of how to form a world wheat price index. Naanwaab and Yeboah (2012) use quarterly grain supply-demand data, relative commodity prices, partial equilibrium analysis, and useful functional forms in analysis of the impact of NAFTA on agricultural commodity trade between Mexico, Canada, and the United States.

### *Objective*

The objective of this research is to analyze the factors affecting the price responsiveness of the disaggregated classes of U.S. wheat exports. Factors examined in this study that are likely to influence U.S. exports on a class-by-class basis include a) wheat prices – own price and cross price effects from wheat classes and competitive substitutes (i.e., feedgrains), b) supply-demand balances by wheat class for major export sellers & import buyers, c) transportation costs for U.S. grain export, and g) exchange rates for the U.S. dollar & other currencies.

Additional factors that are likely to influence class-by-class U.S. wheat exports not explicitly examined in this study but may be examined in futures analysis include 1) the proportion of food versus feed quality wheat by class as is most common in individual exporting and importing countries, and 2) protein and quality factors for U.S. wheat by class.

### **Frameworks for Modeling U.S. Wheat Exports by Class**

Two frameworks have been used to model export supply-demand on a sub-aggregate or class basis. The first framework can be classified as “export competitor models”, while the second may be classified as “world export share” models. Both of these types of models in this study are based on and are variations of a general export model (1).

$$(1) \quad \text{General Model:} \quad \text{Exports}^{\text{US/Other}} = f(\text{Price}^{\text{US/Other}}, \% \text{Stks/Use}, \text{USD}\$, \text{Freight}, \text{Qtrs})$$

The general export competitor model used in this study (1) shows relative U.S. wheat exports by class between two countries as a function of relative prices, percent of world ending stocks-to-use for wheat and corn, the U.S. trade weighted dollar index, ocean freight costs, and the quarterly time period of the year. Because of the potential cross over impact of U.S. corn prices upon wheat exports for alternative classes, a U.S. quarterly corn export model was estimated along with the U.S. quarterly class-by-class wheat models – following the same general model structure.

### *Export Competitor vs World Export Share Models*

Export competitor models rely on relative or comparative export quantity and export price information between specific major export countries or regions along with other selected variables. The key question addressed with U.S. export competitor models is “how do relative prices & other factors affect the exports of the U.S. versus those of individual competing exporters?”

On the other hand, world export share models rely on a country or region’s proportional share of exports for a particular commodity relative to an overall or world total. Similarly, country or region-specific prices in world share models are expressed on a relative basis to an overall world aggregate average or index of related prices. The key question with U.S. export share models is “how do relative prices & other factors affect the market share of the U.S. versus total world exports?”

### *Export Competitor Model Variables*

Descriptions of key variables for the hard red winter wheat export competitor model are given below. The quarterly export (2) and price (3) ratios for HRWW represent U.S. wheat exports as a ratio of those of Argentina, their primary competitor export competitor. Quarterly world wheat ending stocks to use (4) are calculated in the same manner as for world corn stocks-to-use. Quarterly ocean freight cost indices (5) are calculated from USDA estimates of HRWW, SRWW and corn shipping costs from U.S. Gulf of Mexico ports to Japan over time. Similarly, freight cost index calculations for HRSW and SWW represent trends in shipping costs from the U.S. Pacific Northwest (i.e., Portland) to Japan.

(2) Export Ratio: 
$$Expt_{US/ARG}^{HRWW} = \frac{Expt_{US,Yr(i),Qtr(j)}^{HRWW}}{Expt_{ARG,MktgYr(i),Estimate\_Qtr(j)}^{HRWW}}$$

(3) Price Ratio: 
$$Pr_{US/ARG}^{HRWW} = \frac{Pr_{US,Yr(i),Qtr(j)}^{HRWW}}{Pr_{ARG,Yr(i),Qtr(j)}^{HRWW}}$$

(4) Ending Stocks-to-Use: 
$$SU_{Wld}^{Wheat} = \frac{Ending\_Stocks_{World,Yr(i),Qtr(j)}^{Wheat}}{Total\_Use_{World,Yr(i),Qtr(j)}^{Wheat}}$$

(5) Ocean Freight: 
$$Freight_{US-Destn}^{HRWW} = \frac{Ocean\_Freight_{USGulf-to-Japan,Yr(i),Qtr(j)}^{HRWW}}{Ocean\_Freight_{USGulf-to-Japan,1996,Qtr\#3(Dec-Feb)}^{HRWW}}$$

### *U.S. Competitor Export Models by Wheat Class*

The structure of quarterly export competitor models for U.S. HRWW (6), HRSW (7), SWW (8) and corn (9) vary by primary U.S. competitor, but are otherwise similar. The primary competitor for U.S. HRWW is identified as Argentina, as Canada for HRSW, Australia for SWW, and Argentina for corn. Although U.S. SRWW has readily identifiable competitors in the world wheat market, available price series are inadequate to develop a U.S. SRWW export competitor model. However, a U.S. SRWW world export share model will be developed in the next section. The wheat models (6 through 8) represent the impact of cross price effects from other wheat classes, along with quarterly USDA projections of both world wheat and corn projected stocks-to-use and a quarterly average index of U.S. dollar trade weighted currency exchange rates.

Multi-collinearity and related model instability issues play a major role in final model structure. In cases where freight rate variation is closely reflected in export price differentials between competitors, an Ocean Freight (5) variable is collinear with the relative price variable. Similarly,

the presence of quarterly period dummy variables can be a source of model instability if relative price patterns between competitors follow quarterly trends with a degree of regularity. As a result of these factors, the quarterly ocean freight cost variable was excluded in estimation of the HRWW (6) and HRSW (7) models. Variables representing quarterly period impacts were excluded from the HRWW (6) and Corn (9) models for the same reason. The Corn model (9) excluded wheat cross price effects for model stability purposes.

(6) U.S. HRWW Export Competitor Model

$$Expt_{US/ARG}^{HRWW} = f\left(\Pr_{US/ARG}^{HRWW}, \Pr_{US/CAN}^{HRSW}, \Pr_{US/AUS}^{SWW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USD\$}^{WldTrade}\right)$$

(7) U.S. HRSW Export Competitor Model

$$Expt_{US/CAN}^{HRSW} = f\left(\Pr_{US/CAN}^{HRSW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USDollar}^{CAN\$}, Qtrs_{2,3,4}^{Wheat}\right)$$

(8) U.S. SWW Export Competitor Model

$$Expt_{US/AUS}^{SWW} = f\left(\Pr_{US/AUS}^{SWW}, \Pr_{US/ARG}^{HRWW}, \Pr_{US/CAN}^{HRSW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USDollar}^{AUS\$}, Freight_{US-Destn}^{SWW}, Qtrs_{2-4}^{Wheat}\right)$$

(9) U.S. Corn Export Competitor Model

$$Expt_{US/ARG}^{Corn} = f\left(\Pr_{US/ARG}^{Corn}, SU_{Wld}^{Corn}, SU_{Wld}^{Wheat}, \$Exch_{USDollar}^{WldTrade}, Freight_{US-Destn}^{Corn}\right)$$

*Key World Export Share Model Variables*

Although the world ending stocks-to-use variables for wheat and corn (4) and the ocean freight variables (5) are unchanged, key differences exist in the export (10) and price (11) ratios for world export share models (in comparison to the export competitor models described above). Using U.S. HRWW as an example, the export ratio (10) for the U.S. world export share models is calculated as the ratio of quarterly U.S. hard red winter wheat exports to total projected marketing year world wheat exports divided by four (to provide a rough representation of quarterly wheat export shipments).

Although it would have been preferable and in a strict sense more accurate to use actual calculated world wheat export shipments as opposed to a uniform estimate of wheat exports (i.e., the marketing year total divide by four quarters), quarterly data for world wheat export flows are not available from public sources – either in aggregate including all classes or by wheat subclass.

(10) Export Ratio: 
$$Expt_{US/Wld}^{HRWW} = \frac{Expt_{US,Yr(i),Qtr(j)}^{HRWW}}{(Expt \div 4)_{World,Estimate-MktgYr(i),Qtr(j)}^{All\_Wheat}}$$

(11) Price Ratio: 
$$Pr_{US/Wld}^{HRWW} = \frac{Pr_{US,Yr(i),Qtr(j)}^{HRWW}}{Pr_{Avg(USWht+ARG+CAN+AUS),Yr(i),Qtr(j)}^{World\_Wheat}}$$

## U.S. World Export Share Models by Wheat Class

Just as was the case for the export competitor models above, the structure of quarterly world export share models for U.S. HRWW (12), HRSW (13), SWW (14) and SRWW (15) vary by primary U.S. competitor, but are similar in structure. These wheat models (12 through 15) do not include cross price effects from other wheat classes to avoid multicollinearity, given that the prices of these wheat classes are already included in the calculation of the world wheat price index (11). Whereas adequate foreign sourced price data was not available to estimate a soft red winter wheat (SRWW) U.S. wheat export competitor model, it is possible to do so for the world wheat export share model. Conversely, it is not possible to calculate a world corn export share model given the limited publically available sources of non-U.S. corn export related prices.

(12) Hard Red Winter Wheat (HRWW)

$$Expt_{US/Wld}^{HRWW} = f\left(\Pr_{US/Wld}^{HRWW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USD\$}^{WldTrade}, Freight_{US-Destn}^{HRWW}, Qtrs_{2-4}^{Wheat}\right)$$

(13) Hard Red Spring Wheat (HRSW)

$$Expt_{US/Wld}^{HRSW} = f\left(\Pr_{US/Wld}^{HRSW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USDollar}^{WldTrade}, Qtrs_{2,3,4}^{Wheat}\right)$$

(14) Soft White Wheat (SWW)

$$Expt_{US/Wld}^{SWW} = f\left(\Pr_{US/Wld}^{SWW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USDollar}^{WldTrade}, Qtrs_{2-4}^{Wheat}\right)$$

(15) Soft Red Winter Wheat (SRWW)

$$Expt_{US/Wld}^{SRWW} = f\left(\Pr_{US/Wld}^{SRWW}, SU_{Wld}^{Wheat}, SU_{Wld}^{Corn}, \$Exch_{USDollar}^{WldTrade}, Qtrs_{2-4}^{Wheat}\right)$$

Ocean freight rate variation has been closely associated with U.S. wheat price differentials in the world wheat market over time to the degree that the Ocean Freight (5) variable had to be excluded from the HRSW (13), SWW (14) and SRWW (15) models, but not for the HRWW (12) model to avoid multicollinearity issues. However, the inclusion of quarterly period dummy variables was not a source of model instability for the world wheat quarterly models (12 – 15).

## Data

### Exports

USDA export data for different U.S. hard red winter, hard red spring, soft white, and soft red winter wheat classes and for corn was used in this analysis. Quarterly export data for U.S. wheat by class is available back to 1973, while similar quarterly export data is available for U.S. corn since 1975. Marketing year export data for world wheat and corn exports is available from the USDA back to the early 1970s.

Quarterly foreign wheat export data is available for specific countries since at least 1991 by marketing year from either the USDA or International Grains Council. Export data is available for Argentina hard red winter wheat and corn, Canadian hard red spring wheat, and Australian soft white wheat.

### *Prices*

Prices at United States' domestic export locations rather than national average or interior location prices are used to represent competitive international export market bids. Monthly prices that are converted to quarterly averages are available from the USDA for the following locations. Hard red winter wheat prices for Texas Gulf locations (U.S. #1) are available since 1991. Hard red spring wheat prices for Pacific Northwest locations (DNS 14% protein) are available since 1991. Soft red winter wheat prices for the Louisiana Gulf (U.S. #2) are available since 1988. Soft white wheat prices in Portland (U.S. #1) are available since 1973. Corn prices at Louisiana Gulf Ports (Yellow #1) are available since 1975.

Monthly world export wheat and grain prices are available from either the USDA or the International Grains Council since at least 1991 for the following countries and types of grain: a) Argentina hard red winter wheat prices (#2) at export locations, b) Canadian western hard red spring wheat (#1), c) Australian soft white wheat, and d) Argentina maize prices at Up River markets. Although lower quality wheat price series are available at locations such as in Europe (Rotterdam), the price data is too incomplete with skips and a limited number of observations to use in model estimation.

Figure 1 shows price ratio variables over time for the U.S. wheat and corn export competitor models. Included are the U.S. and Argentina hard red winter wheat (HRWW) prices and their ratios since June-August 1991 with their associated ratio (upper left graph). Similar information is included for U.S. and Canada hard red spring wheat (HRSW) prices (upper right graph); U.S. and Australia soft white wheat (SWW) prices (lower left graph); and U.S. and Argentina corn prices (lower right graph).

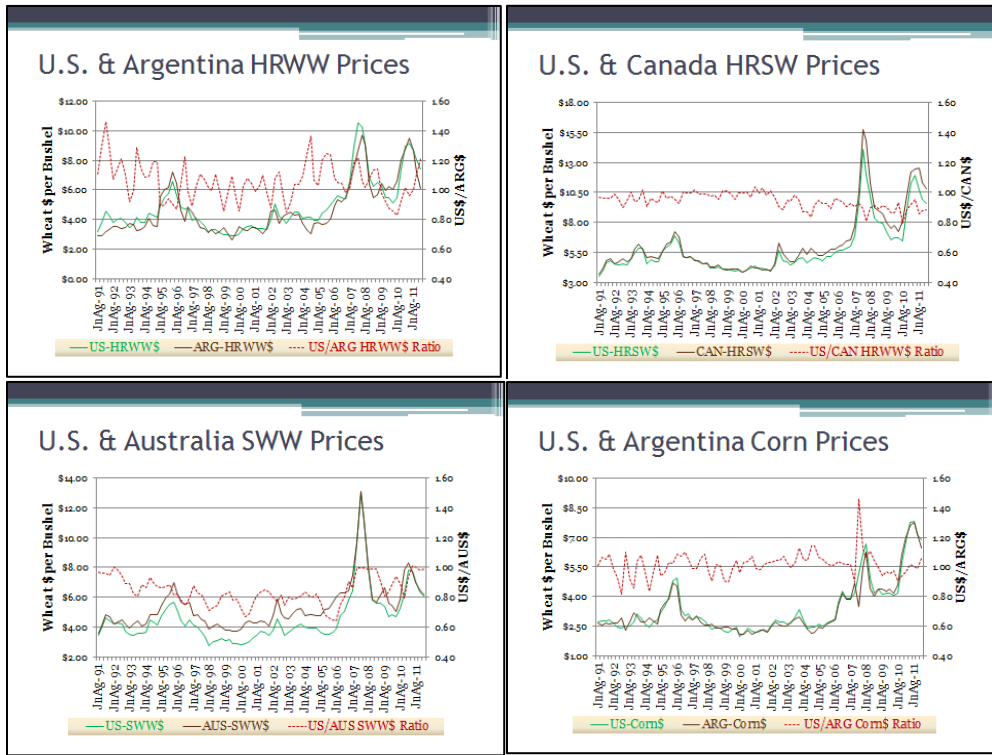
Figure 2 shows price ratio variables over time for the U.S. wheat and corn world export share models. Included are the U.S. hard red winter wheat (HRWW) prices, the World wheat price index, and their ratios since June-August 1991 (upper left graph). Similar information is included for U.S. hard red spring wheat (HRSW) prices (upper right graph); U.S. soft white wheat (SWW) prices (lower left graph); and U.S. corn prices (lower right graph).

### *Wheat and Corn Marketing Year Quarters*

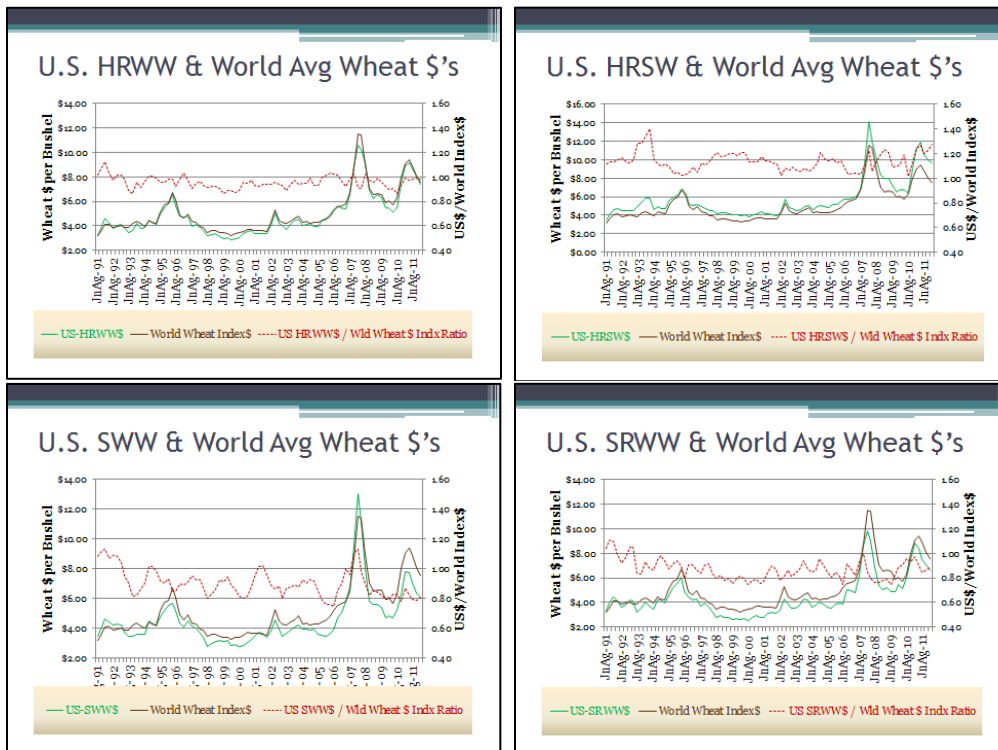
The U.S. wheat marketing year is defined by the USDA as beginning on June 1<sup>st</sup> and lasting till the following May 31<sup>st</sup>. The U.S. wheat marketing year is commonly divided into four "quarters", with the June-August time period designated as the 1<sup>st</sup> quarter of the marketing year, September-November as the 2<sup>nd</sup>, December-February as the 3<sup>rd</sup>, and March-May as the 4<sup>th</sup>. Similarly, the U.S. corn marketing year is defined by the USDA as beginning on September 1<sup>st</sup> and lasting till the following August 31<sup>st</sup>.



**Figure 1. Export Competitor Model Price Ratios**



**Figure 2. World Export Share Model Price Ratios**



The U.S. corn marketing year is also commonly divided into four “quarters”, with the September-November time frame designated as the 1<sup>st</sup> quarter, December-February as the 2<sup>nd</sup>, March-May as the 3<sup>rd</sup>, and June-August designated as the 4<sup>th</sup> quarter of the marketing year. The first quarter is the base model estimation period for both wheat and corn models.

### *Other Model Information*

Monthly ocean freight costs for shipping grain are available from the U.S. Gulf & Pacific Northwest to Japan from the USDA since 1996. Monthly historic trade weighted U.S. dollar indices and currency exchange rate information for the U.S. dollar and Australian, Canadian, and Brazilian currencies from the Saint Louis Federal Reserve Bank. Monthly USDA estimates of world wheat and world corn ending stocks-to-use are estimated and converted to a quarterly basis by using the last monthly quarter estimates, i.e., August for the June-August quarter, November for the September-November quarter, etc.

### **Estimation Results**

Single equation ordinary least squares methods were used to estimate the array of U.S. wheat and corn export competitor and U.S. world wheat export share models in double log functional forms. Due to the log-log forms, the equation coefficients equal price flexibility measures at the means of the explanatory variables. While measures of price elasticity represent the response of quantity demanded to changes in price, price flexibility measures represent the response prices to changes in quantity. Measures of model explanatory ability for overall wheat class and corn exports were low (i.e., less than 50%), but all models were statistically significant in explaining dependent variable data variation (i.e., see model F-test results in each table).

#### *Hard Red Winter Wheat Export Model Results*

Results for the U.S. HRWW export competitor model (Table 1, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus Argentina HRWW had a small negative significant impact on U.S. HRWW exports relative to those of Argentina. For each 1% increase in the relative U.S. HRWW price, U.S. HRWW exports decreased by 1.07%. Regarding cross price flexibility, a relative price increase for U.S. versus Argentina HRSW had a sizable significant negative impact on U.S. HRWW exports relative to those of Argentina. For each 1% increase in the relative U.S. HRWW price, U.S. HRWW exports decreased by 2.89%. Considering currency effects, an increase in the U.S. trade weighted dollar index had a small significant negative impact on relative U.S. HRWW exports, with a 1% increase in the U.S. dollar index causing a 1.02% decrease in U.S. HRWW exports versus those of Argentina. No other explanatory variable effects were statistically significant.

Results for the U.S. HRWW export market share model (Table 1, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus world wheat prices had a significant negative impact on U.S. HRWW exports relative to world totals. For each 1% increase in the relative U.S. HRWW price, U.S. HRWW world wheat export share decreased by 1.83%. Regarding the impact of ocean transportation costs, a 1% increase in U.S. ocean freight cost caused a statistically significant 0.16% decrease in U.S. HRWW world wheat export share.

During the Dec-Feb quarter of the wheat marketing year, U.S. HRWW prices were 0.23% lower than the world wheat price index. No other explanatory variable effects were statistically significant, although world corn stocks to use and the trade weighted U.S. dollar index were nearly so (i.e., at a 10% level of statistical significance.)

**Table 1. U.S. Hard Red Winter Wheat Models (log-log functional form)**

A. U.S. Competitor Model (1991-Q1 to 2012-Q3)			B. U.S. Market Share Model (1996-Q3 to 2012-Q3)		
Variable	Coefficient	t-stat / (p-value)	Variable	Coefficient	t-stat / (p-value)
Intercept	*9.02	9.01 / (0.00)	Intercept	-3.14	-1.37 / (0.18)
Pr\$ <sup>HRWW</sup> <sub>US/Arg</sub>	*-1.07	-2.77 / (0.01)	Pr\$ <sup>HRWW</sup> <sub>US/Wld</sub>	*-1.83	-2.12 / (0.04)
Pr\$ <sup>HRSW</sup> <sub>US/Can</sub>	*-2.89	-3.13 / (0.00)	SU <sup>Wheat</sup> <sub>Wld</sub>	-0.38	-1.47 / (0.15)
Pr\$ <sup>SWW</sup> <sub>US/Aus</sub>	0.56	1.18 / (0.24)	SU <sup>Corn</sup> <sub>Wld</sub>	-0.40	-1.70 / (0.10)
SU <sup>Wheat</sup> <sub>Wld</sub>	0.39	1.16 / (0.25)	USD\$ <sub>WldTrade</sub>	0.70	1.65 / (0.10)
SU <sup>Corn</sup> <sub>Wld</sub>	0.02	0.09 / (0.93)	Freight <sup>HRWW</sup>	*0.16	2.25 / (0.03)
USD\$ <sub>TradePtrns</sub>	*-1.02	-5.71 / (0.00)	wQ2 (Sep-Nov)	-0.07	-0.69 / (0.49)
			wQ3 (Dec-Feb)	*-0.23	-2.23 / (0.03)
			wQ4 (Mar-May)	-1.89	-1.86 / (0.07)
F = 10.86 / 0.00 significance; Adj R <sup>2</sup> = 0.42			F = 3.30 / 0.00 significance; Adj R <sup>2</sup> = 0.22		
* Coefficients statistically significant at the 5% level					

### *Hard Red Spring Wheat Export Model Results*

Results for the U.S. HRSW export competitor model (Table 2, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus Canada HRSW had a significant negative impact on U.S. HRSW exports relative to those of Canada. For each 1% increase in the relative U.S. HRSW price, U.S. HRSW exports decreased by 1.61% relative to Canada. During the Sep-Nov and Mar-May quarters of the wheat marketing year, U.S. HRSW prices were 0.31% and 0.19% higher than Canadian HRSW prices, respectively. No other explanatory variable effects were statistically significant.

Results for the U.S. HRSW export market share model (Table 2, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus world wheat prices had a significant large negative impact on U.S. HRSW exports relative to world totals. For each 1% increase in the relative U.S. HRSW price, U.S. HRSW world wheat export share decreased by 8.35%. An increase in the trade weighted value of the U.S. dollar of 1% increase in U.S. ocean freight cost caused a statistically significant 0.04% decrease in U.S. HRSW world wheat export

share. During the Sep-Nov, Dec-Feb and Mar-May quarters of the wheat marketing year, U.S. HRSW exports relative to world totals were 2.50%, 1.27% and 1.52% higher than during the base June-August period, respectively. No other explanatory variable effects were statistically significant.

**Table 2. U.S. Hard Red Spring Wheat Models (log-log functional form)**

A. U.S. Competitor Model (1991-Q1 to 2012-Q3)			B. U.S. Market Share Model (1991-Q1 to 2012-Q3)		
Variable	Coefficient	t-stat / (p-value)	Variable	Coefficient	t-stat / (p-value)
Intercept	*1.93	4.41 / (0.00)	Intercept	*19.10	5.34 / (0.00)
Pr\$ <sup>HRSW</sup> <sub>US/Can</sub>	*-1.61	-2.07 / (0.04)	Pr\$ <sup>HRSW</sup> <sub>US/Wld</sub>	*-8.35	-2.65 / (0.01)
SU <sup>Wheat</sup> <sub>Wld</sub>	-0.05	-0.21 / (0.83)	SU <sup>Wheat</sup> <sub>Wld</sub>	-0.67	-0.09 / (0.93)
SU <sup>Corn</sup> <sub>Wld</sub>	-0.01	-0.07 / (0.94)	SU <sup>Corn</sup> <sub>Wld</sub>	3.47	0.46 / (0.65)
Exchg <sub>Can\$/US\$</sub>	0.38	1.29 / (0.20)	USD\$ <sub>WldTrade</sub>	*-0.04	-4.54 / (0.00)
wQ2 (Sep-Nov)	*0.31	3.41 / (0.00)	Freight <sup>HRSW</sup>	na	na
wQ3 (Dec-Feb)	0.09	0.96 / (0.34)	wQ2 (Sep-Nov)	*2.50	4.24 / (0.00)
wQ4 (Mar-May)	*0.19	2.03 / (0.05)	wQ3 (Dec-Feb)	*1.27	2.12 / (0.04)
			wQ4 (Mar-May)	*1.52	2.53 / (0.01)
F = 2.34 / 0.03 significance; Adj R <sup>2</sup> = 0.10			F = 6.02 / 0.00 significance; Adj R <sup>2</sup> = 0.30		
* Coefficients statistically significant at the 5% level					

### *Soft White Wheat Export Model Results*

Results for the U.S. HRSW export competitor model (Table 3, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus Australia SWW had no significant negative impact on U.S. SWW exports relative to those of Australia. However, 1% increases in USDA world wheat and corn ending stocks-to-use projections caused U.S. wheat exports relative to Australia to decline by 0.54% and 0.62%, respectively. During the Sep-Nov and Dec-Feb quarters of the wheat marketing year, U.S. SWW exports were 0.34% and 0.25% higher than Australian SWW exports during the base June-August period, respectively. No other explanatory variable effects were statistically significant.

Results for the U.S. HRSW export market share model (Table 3, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. SWW versus world wheat price indices had no significant negative impact on U.S. SWW exports relative to world totals. However, just as in the U.S. export competitor SWW model, 1% increases in USDA world wheat and corn ending stocks-to-use projections caused U.S. wheat exports relative to world totals to decline by 0.54% and 0.29%, respectively. Also, an increase in the trade weighted value of the

U.S. dollar of 1% caused a 2.01% decrease in U.S. exports relative to world totals. During the Sep-Nov and Dec-Feb quarters of the wheat marketing year, U.S. SWW exports were 0.31% and 0.22% higher than its base Jun-Aug world wheat export share. No other explanatory variable effects were statistically significant.

**Table 3. U.S. Soft White Wheat Models (log-log functional form)**

A. U.S. Competitor Model (1996-Q3 to 2012-Q3)			B. U.S. Market Share Model (1991-Q1 to 2012-Q3)		
Variable	Coefficient	t-stat / (p-value)	Variable	Coefficient	t-stat / (p-value)
Intercept	-0.10	-0.15 / (0.88)	Intercept	*1.00	1.95 / (0.05)
Pr\$ <sup>SWW</sup> <sub>US/AUS</sub>	-0.07	-0.18 / (0.86)	Pr\$ <sup>SWW</sup> <sub>US/Wld</sub>	-0.24	-0.81 / (0.42)
SU <sup>Wheat</sup> <sub>Wld</sub>	*-0.54	-2.13 / (0.04)	SU <sup>Wheat</sup> <sub>Wld</sub>	*-0.54	-2.88 / (0.01)
SU <sup>Corn</sup> <sub>Wld</sub>	*-0.62	-2.70 / (0.01)	SU <sup>Corn</sup> <sub>Wld</sub>	*-0.29	-2.06 / (0.04)
Exchg <sub>AUSS/US\$</sub>	-0.12	-0.43 / (0.67)	USD\$ <sub>WldTrade</sub>	*-2.01	-2.16 / (0.03)
Freight <sup>SWW</sup>	0.01	0.09 / (0.93)	Freight <sup>SWW</sup>	na	na
wQ2 (Sep-Nov)	*0.34	3.45 / (0.00)	wQ2 (Sep-Nov)	*0.31	4.71 / (0.00)
wQ3 (Dec-Feb)	*0.25	2.54 / (0.01)	wQ3 (Dec-Feb)	*0.22	3.36 / (0.00)
wQ4 (Mar-May)	0.12	1.27 / (0.21)	wQ4 (Mar-May)	0.10	1.43 / (0.16)
F = 5.16 / 0.00 significance; Adj R <sup>2</sup> = 0.34			F = 7.64 / 0.00 significance; Adj R <sup>2</sup> = 0.36		
* Coefficients statistically significant at the 5% level					

### *Soft Red Winter Wheat Export Model Results*

Results for the U.S. HRSW export competitor model (Table 4, left side) were not calculated for data availability reasons explained above.

Results for the U.S. HRSW export market share model (Table 4, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. SRWW versus world wheat price indices had no significant negative impact on U.S. SRWW exports relative to world totals. During the Dec-Feb and Mar-May quarters of the wheat marketing year, U.S. SRWW exports were 0.46% and 0.42% lower than its base Jun-Aug world wheat export share. No other explanatory variable effects were statistically significant although world wheat ending stocks-to-use were nearly so (i.e., 10% ending stocks-to-use).

**Table 4. U.S. Soft Red Winter Wheat Models (log-log functional form)**

A. U.S. Competitor Model			B. U.S. Market Share Model (1991-Q1 to 2012-Q3)		
Variable	Coefficient	t-stat / (p-value)	Variable	Coefficient	t-stat / (p-value)
na	na	na	Intercept	0.55	0.44 / (0.66)
			Pr\$ <sup>SWW</sup> <sub>US/Wld</sub>	-0.21	-0.24 / (0.81)
			SU <sup>Wheat</sup> <sub>Wld</sub>	-0.68	-1.67 / (0.10)
			SU <sup>Corn</sup> <sub>Wld</sub>	-0.29	-0.92 / (0.36)
			USD\$ <sub>WldTrade</sub>	-0.13	-0.54 / (0.59)
			Freight <sup>SRWW</sup>	na	na
			wQ2 (Sep-Nov)	-0.14	-0.91 / (0.37)
			wQ3 (Dec-Feb)	*-0.46	-2.77 / (0.01)
			wQ4 (Mar-May)	*-0.42	-2.63 / (0.01)

F = 2.92 / 0.01 significance; Adj R<sup>2</sup> = 0.14  
\* Coefficients statistically significant at the 5% level

*Corn Export Model Results*

Results for the U.S. Corn export competitor model (Table 5, left side) were as follows. In terms of own price flexibility, a relative price increase for U.S. versus Argentina corn did not have a statistically significant (i.e., > 5% level of significance) negative impact on U.S. corn exports relative to those of Argentina. However, there was a significant negative impact if one considers the less stringent 10% significance level, with a 1% increase in the relative price of U.S. to Argentina corn causing a 0.77% decrease in U.S. corn exports relative to those of Argentina. Increases in USDA world corn ending stocks-to-use projections were not significant at the 5% level, but were significant at the 11% level for corn ending stocks-to-use for corn and 10% for all wheat. To this end a 1% increase in world corn ending stocks caused a 0.32% increase in U.S. corn exports relative to Argentina. However, increases in world wheat ending stocks caused a statistically significant decline in U.S. corn exports relative to Argentina, with a 1% increase in world wheat ending stocks caused U.S. corn exports relative to Argentina to decline by 0.87%. Also, a 1% increase in the U.S. dollar trade weighted index caused relative U.S. corn exports (versus Argentina) to decrease by 0.59%. No other explanatory variable effects were statistically significant.

Results for the U.S. HRSW export market share model (Table 5, left side) were not calculated for reasons explained earlier.

**Table 5. Corn Models (log-log functional form)**

A. U.S. Competitor Model (1991-Q1 to 2012-Q3)			B. U.S. Market Share Model		
Variable	Coefficient	t-stat / (p-value)	Variable	Coefficient	t-stat / (p-value)
Intercept	*7.01	9.71 / (0.00)	na	na	na
Pr\$ <sup>Corn</sup> <sub>US/Arg</sub>	-0.76	-1.69 / (0.10)			
SU <sup>Corn</sup> <sub>Wld</sub>	0.32	1.60 / (0.11)			
SU <sup>Wheat</sup> <sub>Wld</sub>	*-0.87	-3.44 / (0.00)			
USD\$ <sub>WldTrade</sub>	*-0.59	-5.22 / (0.00)			
Freight <sup>Corn</sup>	na	na			

F = 11.45 / 0.00 significance; Adj R<sup>2</sup> = 0.34  
 \* Coefficients statistically significant at the 5% level

## Discussion and Analysis

Own price responsiveness of U.S. exports in a manner consistent with demand theory (i.e., a negative price-quantity relationship) was found in HRWW & HRSW - the two largest U.S. wheat export classes. Also, cross price responsiveness or interactions were found between U.S. HRWW & HRSW exports, with higher U.S. HRSW wheat prices having a negative impact on U.S. HRWW exports relative to those of Argentina. The impact of varying HRWW protein levels for U.S. wheat on both HRWW and HRSW export demand was not modeled or analyzed in this study, but will be included in future work.

One finding that was partly expected but still somewhat surprising is the “secondary” nature of U.S. SWW and SRWW exports. The results of this study indicated that a reduction in U.S. SWW and SRW wheat exports occur when world wheat and corn supply-demand balances are larger or more abundant. This begs the question of whether the U.S. can or should be considered a “fall back” supplier of SWW and SRWW wheat exports when the world is in short supply of either wheat and/or corn? The preliminary answer to this question appears to be yes.

Another issue raised in this study is that of whether the two primary ports in North America for HRSW (i.e., Portland, Oregon for the U.S., and locations near Vancouver, Canada) are close enough together that ocean freight costs are essentially equal? Seemingly, the answer is yes. Because of the near equality of ocean freight costs and price impacts on U.S. and Canadian HRSW, inclusion of freight cost variables leads to serious multicollinearity problems in these U.S. wheat export models when freight costs are included as an explanatory variable.

A related matter concerns how a grain exporter’s relative geographic location determines how important freight costs are to their market competitiveness. Examples of this are clear in the current world wheat market, with the competitive impact of lower freight costs to the middle east

from the Black Sea region countries of Russia, Kazakhstan and the Ukraine dramatically impacting the relative competitiveness of these countries versus the U.S., Argentina, parts of the European Union, and elsewhere. These same transportation cost issues impact the relative price / cost competitiveness of U.S. and Australian wheat, U.S. and South American corn and soybeans, and other commodities.

Another observation stemming from this study has to do with the limited nature of the world wheat export data on a class by class basis, and by periods of the year less than a full marketing year. A similar situation exists for world corn data. Monthly or quarterly wheat export and data are generally not publically available from many foreign countries outside of select locations that are regularly monitored and reported on by either the USDA or the International Grains Council in London, England. This lack of data availability has forced market analysts and applied researchers to presume broad country-by-country aggregation of wheat varieties by class in these types of wheat class-related analyses.

## **Conclusions**

The objective of this research has been to analyze the factors affecting the price responsiveness of the disaggregated classes of U.S. wheat exports. The approach used has been to develop a set of wheat-class specific models to determine whether wheat and corn exports are impacted by such factors as a) own-class and cross-class prices and prices for competitive substitutes, b) supply-demand balances for world wheat and corn markets, c) transportation costs for U.S. grain exports, d) exchange rates for the U.S. dollar & other currencies, and e) quarterly time period effects .

The study results provide evidence consistent with pre-study expectations of own and cross price impacts for the two major U.S. wheat export classes, i.e., hard red winter and hard red spring wheat. However, model estimation results for U.S. soft white and soft red winter wheat exports go not support these pre-study expectations in that these classes of wheat appear to respond as much or more to alternative market factors as they do to relative changes in their own prices.

This research is only as beginning step in the analysis of factors affecting U.S. wheat exports on a class-by-class basis. To extend this work, these individual equation models need to be combined into a system of equations – using methods such as Seemingly Unrelated Regressions (SUR). In a systems estimation procedure, the price elasticity and/or flexibility measures from individual equations may tend to be less than those from equation systems. An ongoing task will also be to periodically rethink the model structures and functional forms used in this study in order to better address the question of how best to represent U.S./World wheat export market interactions on a class-by-class basis. This includes examination of real-inflation adjusted wheat price series in addition to the nominal prices used up to this point.

And as had been discussed in the introduction, additional factors that are likely to influence class-by-class U.S. wheat exports but that are not explicitly examined in this include 1) the proportion of food versus feed quality wheat by class as is most common in individual exporting and importing countries, and 2) protein and quality factors for U.S. wheat by class. Future applied research efforts will need to account for these factors.



The long range purpose for this research is to provide U.S. government, university and private wheat market analysts with an improved understanding of how U.S. wheat exports have been affected in the past by various key market factors. These findings may be particularly helpful to analysts seeking objective, reliable and reasonably accurate methods for estimating the impact of alternative U.S. and world wheat supply and price scenarios on U.S. wheat export demand –both for aggregate total U.S. wheat export demand, and for disaggregated, class-by-class U.S. hard red winter, hard red spring, soft red winter, hard white, soft white, and durum wheat exports.

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