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Title Demand and Price Comparison Between Hard Red Winter Wheat and White Wheat.

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The main objective of this research was to compare the demand and the price of hard red winter (HRW) wheat and white wheat (WW) to determine the similarities and the differences between these two wheat classes.

Using Granger's causality test with average monthly cash prices and daily Free on Board (FOB) prices, it was determined that HRW adjustment instantaneously causes WW adjustment, and the WW instantaneously causes HRW adjustment. Over one-week periods, HRW causes WW adjustment, but not the reverse.

The factors affecting domestic demand, foreign demand, and carry-over, for HRW and WW were determined. The coefficients of the three equations were estimated by Three-Stage Least Squares (3SLS). It was shown that 1) the U.S. per capita demand for HRW can be explained by the HRW farm price and the lagged demand per capita, 2) the U.S. demand per capita for WW can be explained by the lagged

demand per capita, 3) the foreign demand for HRW can be explained by the lagged foreign demand and by the trade dependency ratio, 4) the foreign demand for WW can be explained by the Japan rice price and by per capita GNP of importing countries, 5) the HRW carry-over equation (dependent variable: the ratio between the HRW farm price and the U.S. loan rate) can be explained by the ending stock and the lagged ratio, and 6) the WW carry-over equation has the same specification as for HRW. The significant variable is the lagged ratio between the WW farm price and the U.S. loan rate.

These two systems of equations for HRW and WW were compared using the Wald test. The Wald test was applied to the combined system of equations, to each independent set of equations, and to selected common coefficients. The results show a difference between the coefficients of HRW and WW system of equations, due to the foreign demand equations and especially from the coefficients of GNP of the country importing HRW and WW and the coefficients of the lagged foreign demand.

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PART 1

INTRODUCTION

United States (U.S.) wheat production is composed of five classes: Hard Red Spring (HRS), Hard Red Winter (HRW), Soft Red Winter (SRW), white (WW), and Durum (D). These wheat classes have different market characteristics, mainly due to their protein content (see Appendix A).

WW is the wheat class produced in the Pacific Northwest, including Oregon, while HRW is the U.S. leading wheat class. WW is important effect to the Oregon economy, but during the last five years, WW profitability has decreased dramatically. As a consequence, the Oregon farmers are trying to diversify their wheat production. One suggestion is to develop some HRW varieties that are able to compete with WW in the Pacific Northwest (PNW).

1-1) COMPARISON OF HRW VERSUS WW

The production of HRW is very important. It is the leading wheat class in the U.S., accounting for about 50 percent of the wheat production, while the percentage for WW is only 8 to 10 percent.

The U.S. areas of production of HRW and WW are different. The heart of HRW production is Kansas, accounting for about one-third of HRW production. Oklahoma, Texas, New Mexico, Colorado, Nebraska, Montana, South Dakota, and Missouri also are important producers. WW, on the other hand, is grown in most of the western states, mainly Washington, Oregon, and Idaho.

The HRW and WW markets and end uses are different depending on their protein content (between 9.5 percent and 14.5 percent for HRW, between 8 percent and 10.5 percent for WW). HRW can be used for U.S. egg noodles such as macaroni and other alimentary pastes, bread, baker rolls, waffles, and muffins. WW can be used to make oriental noodles, kitchen cakes, pie crusts, doughnuts, cookies, and spongy bread.

The yields are also different. WW gives better yield than HRW in national averages. For instance, in 1986, WW yields per acre were 59 percent higher than for HRW. The higher yields probably are due to characteristics of WW varieties, or they could be due to the better potential of the WW production regions. Also, Oregon State University (OSU) has instituted a program in Crop Sciences to develop some specific HRW varieties for the Pacific Northwest (PNW).

The export markets are extremely important for WW, specially from Japan and South Korea. For instance, in 1986, 70 percent of WW production was exported, while 47 percent of HRW was exported. The HRW market is mainly the domestic market.

The HRW and WW carry-over has exploded since the last decade. For instance, in 1986, carry-over represented 96.6 percent of HRW production while the WW carry-over ratio was 82 percent,

The WW per bushel production costs are generally lower than HRW. For instance, in 1986, WW per bushel production cost was 18.4 percent lower than HRW.

The farm price (dollar per bushel) is lower for WW than for HRW while Free On Board (FOB) Gulf of Mexico HRW price and WW FOB Portland WW price are similar.

Appendix A explains in more detail the difference between U.S. wheat classes and gives more information about these statements.

1-2) RESEARCH INTERESTS

The substitution of HRW for WW will occur in Oregon if there is a demand for PNW HRW and if the economic impact is beneficial for Oregon farmers.

Demand is a major component, along with supply, to determine the competitive or equilibrium price. The competitive price is obtained by the intercept between supply and demand. With insufficient demand, the price will decline to the loan rate, and the consequence will be an unanticipated increase in stockpiles and also an increase in government expenditure.

The beneficial impact for the Oregon farmer will be to ensure at least the same profit per acre for HRW than for WW and more income stability. Profit is defined as the total revenue minus total cost.

This research focuses on the first issue, which is the determination of the demand and the price for HRW and WW.

1-3) OBJECTIVES

Following the comparison between HRW and WW, three objectives are assigned to this research: 1) to develop a model to analyze causality between HRW and WW price, 2) to determine factors affecting the demand for HRW and WW, and 3) to determine which coefficients of the explanatory variables of HRW demand equations differ from those of WW.

A) Objective 1: Price causality

The first objective is to develop a model to analyze causality between HRW and WW prices. Does the price of HRW cause the price of WW or does the price of WW cause the price of HRW? The analysis of the relationship between the two wheat prices is done using Granger's definition of causality (simple causality and instantaneous causality). Average monthly cash prices and daily FOB prices (Gulf of Mexico for HRW and Portland for WW) are used under Ordinary Least Squares (OLS) estimates. This objective will be treated in Part 2 of this thesis.

B) Objective 2: Demand determination

The second objective is to determine factors affecting the demand for HRW and WW. Three demand equations are determined for each wheat class: 1) U.S. domestic demand, 2) foreign demand from U.S., and 3) carry-over. These three equations will form a system that will be estimated by Three-Stage Least Squares (3SLS). 3SLS allows use of some endogenous and predetermined variables. Therefore, two different kinds of information are evaluated:

- **External information:** Information not dependent of HRW and WW, such as interest rate, loan rate, and income.
- **Internal information:** Information dependent of HRW and WW, such as price, price of substitutes, and previous demand.

Endogenous and lagged endogenous variables arise from internal information, while exogenous variables arise from the external information.

The hypothesis to test is whether the coefficients of elasticity are significantly different or equal to zero. Coefficients of price, of U.S. income, of foreign income, of exchange rate, of trade dependency ratio, of Australian wheat production, of Cost Insurance Freight (CIF) Japan rice price, of interest rate, and of previous demand will be computed and tested. Most of these variables come from economic theory, some of them need explanation. CIF Japan rice price and Australian wheat production are introduced in the WW foreign demand equation. A hypothesis considers rice as a substitute of WW in the Asian country. Another hypothesis considers Australian wheat as the main competitor of U.S. WW and, therefore, whether Australia's wheat production affects the WW foreign demand. The trade dependency ratio is the ratio between foreign wheat consumption and foreign wheat production. This ratio should affect the U.S. HRW foreign demand. This objective will be treated in Part 3 of this thesis.

C) Objective 3: Comparison between HRW demand and WW demand

The third objective is to determine which coefficients of explanatory variables of HRW demand equations differ from their WW counterparts. The Wald test will allow detection of the coefficient or coefficients that are different from HRW to WW. Therefore, the Wald test will be used with the system of equations jointly, with each set of equations and with some coefficients. This objective will be treated in Part 4 of this thesis.

The conclusion (Part 5) will summarize the results of these three objectives and will give the implications for HRW, for WW, and for Oregon wheat producers.

PART 2

PRICE CAUSALITY

An important issue of this research is to determine the direction of influence between HRW and WW prices. This part corresponds to Objective 1 presented earlier: Does the price of HRW causes the price of WW or does the price of WW causes the price of HRW?

2-1) PREVIOUS WORK

A) Concept of causality

The concept of causality was introduced by Wiener (1956) and C. W. J. Granger (1969). The Wiener-Granger concept has proved useful in econometric analysis because it is closely related to notions of causation developed by philosophers of science and to the conditions of exogeneity set forth decades ago by econometricians (Geweke, 1984).

Determining, causality consists of determining the direction of influence between two variables in a time series.

The simple Granger's model for two variables X, Y is:

$$X_t = \sum_{1}^{n} A_j X_{t-j} + \sum_{1}^{n} B_j Y_{t-j} + E_t$$

$$Y_t = \sum_{1}^{n} C_j X_{t-j} + \sum_{1}^{n} D_t Y_{t-j} + U_t$$

Y_t causes X_t if, and only if, B_j is different from 0. Similarly, in the second equation, X_t causes Y_t if, and only if, C_j is different from 0. If both Bj and C_j are different from 0, there is a feedback relationship between X_t and Y_t.

$$Y_t \dashrightarrow X_t \Longrightarrow \sum_{1}^{n} B_j \neq 0$$

$$X_t \dashrightarrow Y_t \Longrightarrow \sum_{1}^{n} C_j \neq 0$$

Granger expanded the definition of causality and developed a more general model for instantaneous causality:

$$X_t + B_0 Y_t = \sum_{1}^{n} A_j X_{t-j} + \sum_{1}^{n} B_j Y_{t-j} + E_t$$

$$Y_t + C_0 X_t = \sum_{1}^{n} C_j X_{t-j} + \sum_{1}^{n} D_j Y_{t-j} + U_t$$

If the variables are such that this kind of representation is needed, then instantaneous causality is occurring. A knowledge of Y_t will improve the "prediction of goodness of fit of the first equation for X_t."

Y_t instantaneously causes X_t if, and only if:

$$B_0 \neq 0$$

X_t instantaneously causes Y_t if, and only if:

$$C_0 \neq 0$$

In his Econometrica article (1969), Granger noted, "Whether or not a model involving some group of economic variables can be a simple causal model depends on what one considers to be the speed with which information flows through the economy and also on the sampling period of the data used. It might be true that when quarterly data are used, for example, a simple causal model is not sufficient to explain the relationships between the variables while for monthly data a simple causal model would be all that is required. (p. 427)" The choice of the sampling period is an important issue in our effort to determine the causal relationship between HRW price and WW price.

Granger's definition depends on the following assumptions:

a) the variables being tested result from stochastic processes,

b) the series are stationary, and

c) the future cannot cause the past.

A few years after Granger, Sims (1972) developed an alternative testing procedure. The Sims method requires that we "regress Y on past (current) and future values of X, taking account of generalized least squares or prefiltering of the serial correlation. Then, if causality runs from X to Y only, future values of X in the regression should have coefficients insignificantly different from zero, as a group. (p. 545)"

Assume two variables corresponding to a time series Y and X:

$$Y_t = A_0 + \sum_{0}^{m} A_i X_{t-i}$$

$$Y_t = B_0 + \sum_{1}^{n} B_j X_{t+j} + \sum_{0}^{m} B_i Y_{t-i}$$

X_t causes Y_t if, and only if, B_j is different from zero.

$$X_t \text{---->} Y_t \text{=====>} \sum_{1}^{n} B_j \neq 0$$

Before regressing Y_t on X_t, following the Sims procedure, the data must be prefiltered.

Sims wrote, "It is important that the assumption of serially uncorrelated residuals be approximately accurate. Therefore, all variables used in regressions were measured as natural logs and prefiltered using the filter $1-1.5 L + 0.5625 L^2$, i.e., each logged variable X_t was replaced by $X_t - 1.5 X_{t-1} + .5625 X_{t-2}$. (p. 545)"

The Sims procedure does not explain the origin of the filtering equation. Therefore, this procedure is not often used.

B) Limits of causality

Fryar (1986) criticized Bredahl and Green's article published in 1983. Bredahl and Green used the procedure suggested by Granger and Sims to test for causality between world prices, coarse grain exports, and coarse grain acreage. As Bredahl and Green stated, "The explanatory variables do not cause the dependent variable if the coefficients of the current and lagged values of the explanatory variables are not significantly different from zero. (p. 787)" Fryar's criticism was that the Granger and Sims procedure was designed to test the presence of relationship, not to test for its absence due to type 2 error. A type 2 error occurs when we do not reject a hypothesis that is wrong.

Blank and Schmiesing (1988) observed another weakness in the Granger and Sims causality tests. They noted that these tests do not measure the relative strength of relationships. Therefore, the tests are only a classification process designed to describe the relationship between two variables. Thus, in our case, the strength of the relationship between the price of HRW and the price of WW cannot be determined.

C) Previous application

Sims tested the causal relationship between money and income for the period, 1947 to 1969. The results showed the unidirectional causality from money to income, while the hypothesis that income caused money was rejected.

In agricultural markets, there are numerous applications of causality tests.

Bessler and Brandt (1982) found there were strong lead and lag relationships between sow farrowings and hog prices and between cattle prices and cattle on feedlots in the data for the period from 1963 to 1979. The rapeseed futures price was found to cause the soybean price for November 1979 contracts (Carter and Rauser, 1983).

Using the Chicago Soft Red Wheat futures price as proxy for the WW market, Reynolds (1984) concluded that there was no causal link between the cash forward market and the futures market for the September contract during the period from 1980 to 1982.

At OSU, a thesis written by Santisuk Sanguanruang (1986) evaluated the temporal price relationship between cash forward and futures markets for WW and measured the relationships between the two markets in light of the concept of causality with Granger's and Sims' tests. He found a strong causality ran from future prices to cash prices in the September harvest period. Some causality from future prices to cash prices lingered into the December and March storage month delivery periods. There were no causal relationships in other delivery periods except for a feedback from cash price to future price in the March period.

Recently, a study by Blank and Schmiesing (1988) estimated the causal relationship between different marketplaces for HRW prices and corn prices. The test results for corn (#2 yellow corn) indicated that the markets studied (Gulf of Mexico, St. Louis, Chicago, Kansas City, Omaha, Minneapolis) are efficient in that they respond instantaneously to one another. Further, the study showed that the winter wheat market is efficient and has strong signs of price leadership. The Gulf of Mexico was determined to be the market center for HRW for the period of July 1982 to June 1983.

2-2) MONTHLY CASH PRICES STUDY

A) Data Sources

The relationship between the monthly cash prices of HRW and WW will be examined first. The monthly cash prices are published by the USDA in the Wheat Situation and Outlook Yearbook, a publication that is released each February. For HRW, the cash price in Kansas City (#1 ordinary protein) will be used; for WW, the cash price in Portland (#1 soft white) will be used. The monthly cash price is an average of daily observations.

The data cover the period, June 1970 to May 1987. This represents 17 crop years and 204 observations. A long data series is important. As Kmenta (1986) noted, "When the explanatory variable and the disturbance are contemporaneously uncorrelated the classical results of least squared estimation hold only asymptotically. (p. 339)"

A crop year is composed of 12 months, beginning in June and ending in May of the next calendar year. May prices, in theory, reflect 12 storage months and, therefore, should be higher than June prices. To avoid this disturbance, the data need to be deseasonalized.

B) Methodology

The first operation is to deseasonalize the data.

1) Deseasonalized Data

Judge, Hill, Griffiths, Lutkepohl and Lee (1982) suggested a method for deseasonalisation, in which the seasonal mean is subtracted from each month. For instance, the average of all January figures is subtracted from each January observation, and so on for each month. Then, the overall mean of the original series is added to the resulting figures.

In practice, 12 dummy variables corresponding to the 12 months of the crop year ($d_1 \ldots d_{12}$) are included. Then, they will be fitted by an OLS, where the dependent variable will be the cash price and the independent variables will be the dummy variables:

$$P_{hrw} = F(d_1 \ldots d_{12}) \; ; \qquad (1)$$

$$P_{ww} = F(d_1 \ldots d_{12}) \; ; \qquad (2)$$

where:

P_{hrw} = HRW cash price; and

P_{ww} = WW cash price.

Using the dummy variable coefficients ($a_1 \ldots a_{12}$), the following formula is applied:

$$Ph_t = (P_{hrwt} - a_{hrwt}) + Pm_{hrw} \; ; \qquad (3)$$

$$P_{wt} = (P_{wwt} - a_{wwt}) + Pm_{ww} \; ; \qquad (4)$$

where:

Ph_t = result of equation (3) for HRW at time t;

P_{wt} = result of equation (4) for WW at time t;

P_{hrwt} = cash price of HRW observed at time t;

P_{wwt} = cash price of WW observed at time t;

Pm_{hrw} = mean cash price for HRW;

Pm_{ww} = mean cash price for WW;

a_{hrwt} = coefficient of the dummy variable for HRW from equation (1); and

a_{wwt} = coefficient of the dummy variable for WW from equation (2).

2) Granger's procedure

Because of its relative simplicity and the absence of a filter, Granger's procedure is the most used and, is the one used in this study.

To use Granger's test, we need to determine the restricted equation (i.e., regress the lag of cash prices on its current price). Twelve lags, corresponding to each month of one crop year, are choosen. Therefore, the number of observations must be reduced to 192 since the last data set has no lag. The formula is given:

$$P_{ht} = \sum_{1}^{12} \alpha_i P_{ht-i} \qquad (5)$$

$$P_{wt} = \sum_{1}^{12} \alpha_j P_{wt-j} \qquad (6)$$

Then, for each class of wheat, two unrestricted equations are estimated; one to determine the simple causality, the other to determine the instantaneous causality.

The simple unrestricted equations are:

$$P_{ht} = \sum_{1}^{12} \alpha_i P_{ht-i} + \sum_{1}^{12} \beta_i P_{wt-i} \qquad (7)$$

$$P_{wt} = R_{1}^{12} a_j P_{wt-j} + R_{1}^{12} \beta_j P_{ht-j} \tag{8}$$

$$P_{ht} = R_{1}^{12} a_i P_{ht-1} + R_{1}^{12} c_i P_{wt-1} \tag{9}$$

$$P_{wt} = R_{1}^{12} a_j P_{wt-j} + R_{1}^{12} c_j P_{ht-j} \tag{10}$$

The difference between the simple unrestricted equations and the instantaneous unrestricted equations is the addition, for the instantaneous unrestricted equations, of the prices of the assumed causal wheat at the time as that for the dependent-caused wheat rice (t_0).

Thus, two restricted equations [(5) and (6)], two simple unrestricted equations [(7) and (8)], and two instantaneous unrestricted equations [(9) and (10)] have been defined. Now, we have to test the hypothesis that HRW price causes the WW price and/or the WW price causes the HRW price.

3) Hypothesis tested

i) likelihood ratio test

To check for causality, the likelihood ratio test is used. The likelihood ratio test is based on the idea that, if the restrictions are true, the value of the likelihood function maximized with the restriction imposed cannot differ greatly from the value of the likelihood function maximized without the imposition restrictions (Kmenta, 1986).

The formula for the likelihood ratio test used is:

$$LR = -2(LKr - LKu) = X^2 \; ; \tag{11}$$

where:

LR = likelihood ratio;

LKr = value of the log of the likelihood function for the restricted equation;

LKu = value of the log of the likelihood function for the unrestricted equation; and

X^2 = chi square statistic.

Using the previously defined equations, the hypothesis will be tested with the likelihood ratio test (11).

ii) Causality tests

Test causality from HRW price to WW price

The detection of the causal relationship between the price of HRW and the price of WW involves testing the coefficients of equation (8) under the following hypotheses (H_0, H_1):

$$H_0: \sum_{1}^{12} b_j = 0 \tag{12}$$

$$H_1: \sum_{1}^{12} b_j \neq 0 \tag{13}$$

If H_0 is true, the hypothesis that HRW price does not cause WW price cannot be rejected. It is detected by the likelihood ratio being inferior to the chi-square statistic ($LR < X^2$). If H_1 is true, the hypothesis that HRW price does not cause WW price is rejected. It is detected by the likelihood ratio being greater than the chi-square statistic ($LR > X^2$).

Test instantaneous causality from HRW price to WW price

A similar hypotheses for instantaneous causality is formed using the coefficients of equation (10):

$$H_0: \sum_{0}^{12} \gamma_j = 0 \qquad (14)$$

$$H_1: \sum_{0}^{12} \gamma_j \neq 0 \qquad (15)$$

If H_0 is true, the hypothesis that the price of HRW does not instantaneously cause the price of WW is not rejected. If H_1 is true, the hypothesis that the price of HRW does not instantaneously cause the price of WW is rejected.

Test causality from WW price to HRW price

Similarly, the detection of the causal relationship between the price of WW consists of testing the coefficients of the equation (7) under the following hypotheses (H_0, H_1):

$$H_0: \sum_{1}^{12} b_i = 0 \qquad (16)$$

$$H_1: \sum_{1}^{12} b_i \neq 0 \qquad (17)$$

If H_0 is true, the hypothesis that WW price does not cause HRW price cannot be rejected. If H_1 is true, the hypothesis that WW price does not cause HRW price is rejected.

Test instantaneous causality from WW price to HRW price

A similar hypotheses for instantaneous causality is formed using coefficients of equation (9):

$$H_0: \sum_{0}^{12} \gamma_i = 0 \tag{18}$$

$$H_1: \sum_{0}^{12} \gamma_i \neq 0 \tag{19}$$

If H_0 is true, the hypothesis that the price of WW does not instantaneously cause the price of HRW cannot be rejected. If H_1 is true, the hypothesis that WW price does not cause HRW price is rejected.

C) Results

1) HRW price causes WW price

The values of the log of the likelihood function (LK) are 41.35 for the restricted equation (6) and 49.65 for the unrestricted equation (8). Applying equation (11), we find 16.58 for the value of the likelihood ratio (LR). Since the value of X^2 (five-percent level) given for 12 restricted coefficients is 21.026, we cannot reject H_0 (i.e., $LR < X^2$) and, therefore, cannot reject the hypothesis that the price of HRW does not cause the price of WW.

2) HRW price instantaneously causes WW price

Equation (10) gives 201.59 for the value of the log of the likelihood function (LK). We can form our hypothesis with equation (6) as the restricted equation and equation (10) as the unrestricted equation. The likelihood ratio (LR) is 320.48. Since the value of X^2 (five-percent level) given for 13 restricted coefficients is 22.362 (i.e., $LR > X^2$). We can reject the hypothesis that the price of HRW does not instantaneously cause the price of WW. Therefore, HRW price instantaneously causes WW price when the data represent a monthly average price.

3) WW price causes HRW price

In this case, the restricted equation is equation (5) with 40.88 for the value of the log of the likelihood function. The unrestricted equation is equation (7) with 45.88 for value of the log of the likelihood function. The likelihood ratio (LR) is 10. Since the value of X^2 is 21.026 (i.e., $LR < X^2$), at the five-percent level, we cannot reject the hypothesis that the price of WW does not cause the price of HRW when lags are used.

4) WW price instantaneously causes HRW price

To test whether the WW price instantaneously causes the HRW, the restricted equation (5) is used and the unrestricted equation (9) with a value of the log of likelihood of 197.61. The likelihood ratio is 313.46. Since the value of X^2 is 22.362 (i.e., $LR > X^2$), we can reject at the five-percent level the hypothesis that the price of WW does not cause the price of HRW. Therefore, we conclude that the price of WW instantaneously causes the price of HRW.

D) Conclusion

Using a monthly average price, it was found that the price of HRW instantaneously causes the price of WW and, similarly, the price of WW instantaneously causes the price of HRW. As described by Granger, a feedback relationship exists between the price of HRW and the price of WW.

Otherwise, we cannot detect a relationship between the monthly price of HRW and the price of WW; but, what if the time period were one day, rather than one month? Would the same relationships hold?

2-3) DAILY FOB PRICES STUDY

To test the use of daily prices, the daily price quote taken every Thursday is used. Thus, we are looking at causality between daily quotes but taken only once a week on Thursday. The methodology will be the same as used for the monthly data, except for several small changes which will be explained.

A) Data Sources

The daily data used are published by U.S. Wheat Associates under the title "Weekly Wheat Price Report." For HRW, we used the net FOB vessel price at the Gulf of Mexico (ordinary protein). For WW, we used the net FOB vessel price at the Pacific Northwest harbor.

The data cover the time period from January 1980 to December 1987, which represents 7 years or 410 observations.

The prices were obtained from a telephone survey of exporters and do not represent an offer either to buy or sell wheat (U.S. Wheat Associates). Values reflect an average of that day's export quotes, but not necessarily the value of any particular cargo. Various factors, including freight costs and quality requirements affect specific offering prices. This means, each week, we have a price quotation corresponding to Thursday's average price.

Following the procedure defined for monthly cash prices, the first operation is to deseasonalize.

B) Methodology

1) Deseasonalized data

The daily data are deseasonalized by substracting the monthly mean following the procedure defined for monthly cash prices.

2) Granger's procedure

Granger's procedure is used as before, the only difference is in the time lag used. One lag corresponds to 1 week, and therefore, three lags will be used to avoid collapse of the results obtained with monthly data. We also will determine the restricted equations (i.e., price at time t is a function of its own lag prices), the simple unrestricted equations (i.e., in addition, we incorporate the lag of the other wheat) and the instantaneous unrestricted equations (i.e., in addition, we incorporate the current lag of the other wheat).

3) Hypothesis Tested

Following the same procedure, the likelihood ratio test and the same definition of hypotheses previously defined are used.

C) Results

1) Results for HRW price causes WW price

The restricted equation becomes:

$$P_{wwt} = \sum_{1}^{3} \alpha_j \; P_{wwt-j} \qquad (20)$$

where the log of the likelihood function is 407.79.

The simple unrestricted equation becomes:

$$P_{wwt} = \sum_{1}^{3} \alpha_j P_{wwt-j} + \sum_{1}^{3} \beta_j P_{hrwt-j} \qquad (21)$$

where the log of the likelihood function is 412.10.

The hypotheses to test are:

$$H_0: \sum_{1}^{3} \beta_j = 0 \text{ and} \qquad (22)$$

$$H_1: \sum_{1}^{3} \beta_j \neq 0 \ . \qquad (23)$$

The likelihood ratio (LR) gives 8.62, while at the five-percent level, the X^2 with 3 unrestricted coefficients is 7.81. Therefore, at the five-percent level, we reject the hypothesis that the price of HRW does not cause the price of WW. (Note: At the 2.5-percent level, we cannot reject this hypothesis.)

The instantaneous unrestricted equation becomes:

$$P_{wwt} = \sum_{1}^{3} \alpha_j P_{wwt-j} + \sum_{0}^{3} \gamma_j P_{hrwt-j} \ , \qquad (24)$$

where the log of the likelihood function is 485.003.

The hypotheses to test are:

$$H_0: \sum_{0}^{3} \gamma_j = 0 \text{ and} \qquad (25)$$

$$H_0: \sum_{0}^{3} \gamma_j \neq 0 \ . \qquad (26)$$

The likelihood ratio gives 154.426, while at the five-percent level, the X^2 with 4 restricted coefficients is 9.488. (Note: the likelihood ratio is highly significant even at the 0.5-percent level.) We have an improvement from equation (21) to equation (24). We can reject the hypothesis that the price of HRW does not instantaneously cause the price of WW.

2) Results for WW price causes HRW price

The restricted equation becomes:

$$P_{hrwt} = \sum_{1}^{3} \alpha_i \; P_{hrwt-i} \;, \tag{27}$$

where the log of the likelihood function is 302.488.

The simple unrestricted equation becomes:

$$P_{hrwt} = \sum_{1}^{3} \alpha_i \; P_{hrwt-i} + \sum_{1}^{3} \beta_i \; P_{wwt-i} \;, \tag{28}$$

where the log of the likelihood function is 306.016

The hypotheses to test are:

$$H_0 \colon \sum_{1}^{3} \beta i = 0 \text{ and} \tag{29}$$

$$H_1 \colon \sum_{1}^{3} \beta_i \neq 0 \; . \tag{30}$$

The likelihood ratio gives 7.056, while at the five-percent level, the X^2 with 3 restricted coefficients is 7.8. Therefore, at the five-percent level, we cannot reject the hypothesis that the price of WW does not cause the price of HRW.

The instantaneous unrestricted equation becomes:

$$P_{hrwt} = \sum_{1}^{3} \alpha_i \; P_{hrwt-i} + \sum_{0}^{3} \gamma_i \; P_{wwt-i} \;, \tag{31}$$

where the log of the likelihood function is 378.92

The hypotheses to test are:

$$H_0: \sum_{0}^{3} \gamma_i = 0 \text{ and} \tag{32}$$

$$H_1: \sum_{0}^{3} \gamma_i \neq 0. \tag{33}$$

The likelihood ratio gives 152.86, while at the five-percent level, the X^2 with four restricted coefficients is 9.488. Therefore, the hypothesis that the price of WW does not instantaneously cause the price of HRW can be rejected.

D) Conclusion

When daily prices are used, we find that the price of HRW instantaneously causes the price of WW. Likewise, the price of WW instantaneously causes the price of HRW. A feedback relationship exists between the daily price of HRW and the daily price of WW. This feedback occurs in less than one day.

Also, a low tendency for the daily HRW price to cause WW price over a weekly period is detected. Over one week, the relationship cannot be detected.

Further research could focus on reducing the time lag to one day or less.

2-4) GENERAL CONCLUSION

Using monthly cash prices between HRW in Kansas City and WW in Portland, an instantaneous relationship between the price of HRW and the price of WW is detected. Over a one-month period, no relationship was detected. This means that during a one-month period, HRW price causes WW price, and WW price causes HRW price, creating a feedback relationship.

When we use daily price with weekly lag, FOB vessel prices between HRW at the Gulf of Mexico and WW at the PNW port, we also detect an instantaneous relationship between the price of HRW and the price of WW. Over a period of 1 week, we can detect, with a low level of significance, a causality effect from HRW price on WW price, however, the reverse is not true. Therefore, in a day, HRW causes WW price and WW price causes HRW price. Over 1 week, with a low level of significance, HRW price causes WW price; however, the relationship is only one way.

PART 3

HARD RED WINTER AND WHITE WHEAT DEMAND EQUATIONS

In Part 2 of this thesis, the causal relationship between HRW price and WW price was determined. Part 3 will focus on HRW and WW demand side in order to complete Objective Number Two: What factors affect the demand of HRW and WW?

3-1) PREVIOUS WORK

Generally, previous studies have not considered different varieties of wheat as separate commodities. This is due to the difficulty of obtaining data for each wheat class and to the high rate of substitution between wheat classes. McCalla (1966), Taplin (1969), and Alaouze, Watson, and Sturgess (1978) studied wheat as a homogeneous commodity. Alaouze, Watson, and Sturgess noted: "This assumption is plausible because wheats of different grades are closely substituted, the elasticity of substitution between soft and hard wheat is high enough for the pricing policies of the minor exporters to erode the total market shares of one or more of the duopolists. (p. 174)" ("Duopolists" refers to Canada and U.S.)

On the other hand farm organizations such as Oregon Wheat Commission (OWC) want to consider different wheat classes with the intent of differentiating among the wheat classes of their members.

A) Wheat marketed by classes

Pacific Northwest Soft Wheat Association publishes "Wheat Products for the World." This document specifies the market characteristics of WW and explains why the consumer should prefer WW to other wheat classes for certain end uses. The arguments are given: soft white wheat (SWW) gives the most tender pastries, the tastiest flat breads, the highest quality noodles, the best blending quality, and it is a superior milling wheat whose white color is preferred by world consumers.

Likewise, U.S. Wheat Associates and USDA's Foreign Agricultural Service (FAS) cosponsor a brochure about U.S. wheat called: U.S. Wheat <year>, Crop Quality Reports. This publication, in an attempt to help the wheat user, and published each year since 1980, gives the grading and quality factors for each class of wheat produced in the U.S.

The USDA Federal Grain Inspection Service (FGIS) publishes a similar survey, which began in 1985 entitled: U.S. Wheat Quality Report, <year>.

The official interest in marketing each wheat class separately is relatively new.

OSU and Washington State University (WSU) have conducted several studies about WW; (i.e., "The Korean Market for U.S. White Wheat;" Wagenblast, MacDonald, Gonarsyah, Martin, 1984).

The purpose of this study is to 1) describe the recent history of U.S.-Korean wheat trade, 2) describe the Korean wheat importing system, 3) analyze the economic and noneconomic factors which have resulted in WW trade growth, and 4) generalize from the Korean case to the extent possible about market potentials in other newly industrialized developing economies. This study determines the market specificity of one of the two most regular WW importers.

The cooperative extension service of WSU published Factors Determining the Price of White Wheat in the Pacific Northwest in

1974. This publication consists of eight different papers, one of them being "Factors Affecting Demand for White Wheat" (Menze).

Menze noticed that "Japan has always had the ability to finance its purchase and to pay the price including a premium if necessary for WW. (p. 34)" Furthermore, he observed that India maintains a preference for WW provided that the price is reasonably in line with competing varieties, while Pakistan and Bangladesh are strictly a "price buyer" (WW is shipped only when it is as cheap or cheaper than competing varieties). Concerning WW competitors, he emphasized the fact that Australia is the main competitor of the U.S., and that Australian wheat is regarded as a soft WW or yellowish in color, with protein around 11 to 11.5 percent. (Australian WW is higher in protein than U.S. WW.) According to Menze "WW will nearly always respond to whatever influences affect all wheat prices, but demand and supply considerations peculiar to WW may cushion, or exaggerate, the other effects.... When the market moves up sharply, buyers quickly look for the cheapest or most attractive ownership.... The price of WW and other wheats will tend to maintain a close relationship. (p. 21)"

Robert L Sargent, WSU marketing specialist, published an article in 1982 entitled, "When Should I sell My Wheat?" He identifies four factors that influence WW price: 1) world wheat production and utilization, 2) Australian wheat production and stocks, 3) PNW WW production and stocks, and 4) domestic and international political events. All these factors will be discussed later.

B) Wheat: an econometric approach

Numerous researchers have tried to calculate U.S. wheat demand. For instance the USDA has published Demand and Price Structure for Wheat (Meinkin, November 1955), Demand and Price Relationships for the U.S. Wheat Economy (Wheat Outlook and Situation Report, Barr, November 1973), and The U.S. Wheat Economy in an International Setting: an Econometric Investigation (Gallagher, Lancaster, Bredahl, and Ryan, Technical Bulletin # 1644).

The methodology defined by Meinkin (1955) has influenced all other studies of the same topic by the USDA and other researchers. Meinkin formulated six equations to describe demand for domestic food, feed, seed, exports, carryover, and world price for the periods 1921 to 1929 and 1931 to 1938, using limited information and least squares methods. He used per capita consumption as the dependent variable and the average wholesale price of #2 HRW (at Kansas City) per bushel, as the independent variable. He obtained an identical elasticity of -0.04 by both methods. He recognized the limitation of his analysis by stating, "One limitation of the system of equations is that it treats all wheat as a homogeneous commodity. The coefficients obtained for the system can be thought of as an average of those for the separate class of wheat. Data are not available to fit separate equations for the individual classes, but it is possible that further research will permit the development of supplemental equations for these. (p. 1)"

Kahlon (1961) estimated the parameters of individual food demand equation for HRS, HRW and SRW by least squares with consumption as the dependent variable, and prices, income, and quality characteristics of wheat as independent variables for the years 1946 to 1957. The coefficients of price elasticities for HRW and HRS were insignificant, but price elasticity for SRW was estimated at -1.20 at a 10-percent level of significance. Kahlon stressed that the estimated elasticities need to be used with caution because of the inadequacy of the data and the bias inherent in the least-squares approach used in the estimation of the coefficients.

Chai Ju Chun, in 1967, estimated the parameters of individual food demand equations for the five U.S. wheat classes, using the least squares method. The demand for each class of wheat depended on the price and quality of the class, prices and qualities of competing classes, per capita consumer disposable income, the degree of urbanization, and the level of milling and baking technology. The time period covered was 1929 to 1963, (excluding the war years of 1942 to 1945). The price elasticity of demand for HRW was -1.37; HRS -1.41; durum -1.36; SRW -0.36 and WW -0.22 (see table of results in Appendix B). Chai Ju Chun noted that "The price elasticities of individual classes tend to be more elastic than that for all wheat. (p. 150)."

Henning, in 1986, determined an econometric model of the world wheat market by class. Henning created his own wheat classes based on physical characteristics that were related to the major end uses of wheat. For instance, WW was combined with French and Canadian winter wheat. HRW was combined with Argentina and Australian wheat. His classification was criticized by R. Sargent who considered Australian wheat to be the main competitor for U.S. WW. The price elasticities of U.S. domestic demand were estimated by Henning as follows: HRS -1.51, HRW -1.82, SRW and WW -2.42, and durum -0.36 (see Appendix C).

C) Wheat environment

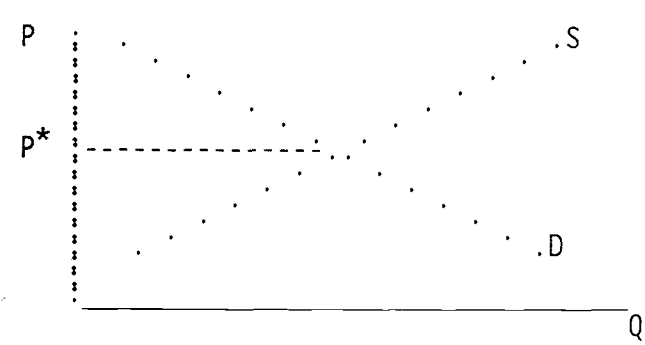
Chambers and Just (1979) have stated that the exchange rate is an important variable for the agricultural trade model. They criticized approaches which simply use own price adjusted by the exchange rate. They contend that such an approach is restrictive and may create bias in the resulting analysis. For them, the exchange rate must be included separately in the demand equation. They conclude in their article, "The results of this paper suggest that much of the problem of measuring rate impacts in agriculture are due to lack of appropriate price indices for certain commodity bundles.... (p. 256)"

3-2) METHODOLOGY AND DATA DISCUSSION

The concept of supply and demand is basic to economic theory. In the normal case, the supply curve is upward sloping, while the demand curve is downward sloping. The intercept between the supply and the demand curves gives the equilibrium or competitive price.

Figure 1

Supply and Demand curves



Where P^* is the equilibrium price.

In the simple model:

The supply equation is formulated as follows:

$$q = S(p) \text{ where } \delta q/\delta p > 0 .$$

The demand equation is formulated as follows:

$$q = D(p) \text{ where } \delta q/\delta p < 0 .$$

Equilibrium is reached when:

$$S(p) = D(p) .$$

However, the complete model is more complicated. Supply and demand are functions of their own price, along with other factors such as consumer income. We can rewrite the supply and demand equations as follows:

$$q = S(p,\varnothing_s) \text{ and}$$

$$q = D(p,\varnothing_d) ;$$

where:

$\varnothing_s$ = factors other than P affecting supply and

$\varnothing_d$ = factors other than P affecting demand.

The delay between seeding and harvesting (almost 9 months) is a specificity of agricultural crops. At harvest time, a farmer figures an expected price for the post harvest period, which is a function of the price at the seeded period (P_{t-1}). The supply function becomes:

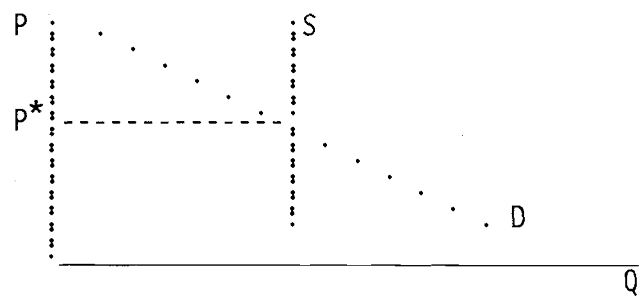
$$q = S(p_{t-1},\varnothing_s)$$

where p_{t-1} is the price of the previous crop year.

Therefore, the short run supply curve becomes inelastic with a coefficient of elasticity equal zero (meaning no price effect at the period t on the quantity). The diagram becomes:

Figure 2

Supply and Demand curves: Wheat cases



The equilibrium price (or competitive price) is the intercept between the supply and the demand curves. Figure 2 shows a vertical supply curve with a coefficient of elasticity equal zero. Only a shift in the demand curve occurring by $\emptyset_d$ can determine the equilibrium price P^* (or competitive price). This thesis will try to estimate the factors than can shift the demand curve to the left or right; therefore, shifting the competitive equilibrium up or down.

A) Econometric specification

Data limitations prohibit the estimation of the six-equation system defined by Meinkin (1955) for each wheat class; however three equations per wheat class will be computed corresponding to domestic demand, foreign demand, and carry-over. Knowing that total demand in equilibrium must equal total supply, a simultaneous equation system needs to be estimated. Kmenta (1986) gives the following definition: "a model is said to constitute a system of simultaneous equations if all of the relationships involved are needed for determining the value of at least one of the endogenous variables included in the model. (p. 652)" This leads to a distinction between two kinds of variables: those that are explained by the model (called endogenous), and those that contribute to provide an explanation (predetermined: exogenous and lagged endogenous variables). A simultaneous equation system must satisfy the rule that the number of predetermined variables is at least equal to the number of endogenous variables (identification process). The Ordinary Least Squares (OLS) method of estimation, applied to the structural equations of a simultaneous equation, leads to inconsistent estimates due to the correlation between the endogenous variables and the error term.

1) Three-Stage Lease Squares method (3SLS)

When we have an overidentified structural equation (more predetermined than endogenous variables), an efficient method of obtaining the structural coefficients in the model is the 3SLS.

Judge, Hill, Griffiths, Lutkepohl and Lee (1982, p. 382) gives the procedure for 3SLS:

- Stage 1 consists of regressing each jointly dependent variable on all the predetermined variables to obtain the reduced form parameter estimate:

$$\hat{\pi} = (x'x)^{-1}x'y \ ,$$

and obtain the calculated values of $\hat{y}$:

$$\hat{y} = x(x'x)^{-1}x'y \ .$$

- Stage 2 consists of estimating δ in order to form the residual covariance matrix $\hat{\Sigma}$. $\hat{\Sigma}$ is then computed by using 2-Stage Least Squares.

- Stage 3 consists to use $\hat{\Sigma}$ to obtain the 3SLS estimator δ.

As we will see later, the equation system is overidentified and the 3SLS method will be used.

2) Autocorrelation

Autocorrelation can occur when time series are used. Autocorrelation occurs when the error terms (ϵ) are as follows:

$$\epsilon_t = \rho\ \epsilon_{t-1} + \mu_t ,$$

where:

ρ = coefficient of correlation.

We want to test if:

$$H_0:\ \rho = 0 \text{ and} \qquad (34)$$

$$H_1:\ \rho \neq 0\ . \qquad (35)$$

If H_0 is true, autocorrelation does not exist. If H_0 is not true, autocorrelation exists.

With autocorrelation, the covariance matrix of error terms becomes different from zero ($Cov(\epsilon_i, \epsilon_j) \neq 0$). The least squares estimators are still unbiased but do not have the smallest variance among all unbiased estimators and, therefore, the estimators are not efficient.

The most popular autocorrelation test is the Durbin-Watson (DW) test. This test is not applicable when the explanatory variable is a lagged dependent variable.

B) Data discussion

1) Data sources

The annual data covers the time period from 1962 to 1985.

The data come from the USDA, <u>Wheat Outlook and Situation, Yearbook</u>." Specific data used include:

1) wheat production by wheat classes (million bushels),

2) beginning stock by wheat classes (million bushels),

3) domestic use by wheat classes (million bushels),

4) exports by wheat classes (million bushels),

5) Australian wheat production (million bushels),

6) world wheat production (million metric tons), and

7) world wheat consumption (million metric tons).

Each year after harvest (August, September or November) the USDA publishes the <u>Wheat Situation and Outlook Report</u>. This report gives the U.S. wheat export by class and by country (thousand bushels).

Grain Market News, a branch of the USDA, furnishes the U.S. FOB price by wheat classes. The FOB prices are 1) for HRW, FOB Gulf of Mexico, # 1, ordinary protein; and 2) for WW, FOB Pacific Northwest port, #2 or better.

The farm prices (prices received by farmers) also are used. For HRW, it was assumed that 100 percent of the wheat produced in Oklahoma and Kansas is HRW. The state wheat farm prices are weighted by the corresponding state wheat production and an average wheat farm price for HRW is found. For WW, it was assumed that 100 percent of the wheat produced in Washington and Oregon are WW. Then, the state wheat farm prices are weighted by the corresponding state wheat production and an annual average wheat farm prices for WW is found. These prices are estimated by the USDA for all states considered, except for Oregon (estimation done by OSU).

According to the USDA, 100 percent of the wheat planted in Kansas and Oklahoma in 1985 was HRW, 100 percent of winter wheat and 99 percent of spring wheat planted in Oregon was WW, and 85 percent of winter wheat and 52 percent of spring wheat planted in Washington was WW. The percentage may have changed during the time period, but the change is not thought to be significant.

The U.S. Gross National Product (GNP) per capita is estimated by the World Bank and divided by U.S. Consumer Price Index (CPI). The U.S. population is estimated by the United Nations (UN). The Consumer Price Index (CPI, base 1967=100) comes from the Department of Labor (Bureau of Labor Statistics). The U.S. interest rate comes from "The Economic Report of the President" and corresponds to the yield on commercial paper for six months.

The world's major economic data comes from the World Bank and the United Nations (UN) as follows:

1) The GNP per capita per country comes from the World Bank (dollar per capita) and
2) The exchange rate for each country is a UN estimate (dollar per foreign currency).

The CIF (Cost Insurance Freight) rice price in Japan is estimated by the UN (External Trade Statistic) and calculated by dividing the total value of imported rice by the total volume (metric tons) of imported rice ($/mt).

2) Data transformation

First, world wheat production and consumption are transformed from million metric tons (MT) to million bushels by multiplying the amount by 36.76 (wheat transformation rate). The rice price of dollars per MT into dollars per bushel is not calculated because the rate of transformation (bushels per MT) changes with the commodity.

Second, all the nominal prices are deflated by the U.S. CPI to obtain real prices.

Third, the exchange rate index is calculated by:

1) using 1985 as a base year. All the foreign currencies were forced to have the same exchange rate with the dollar in 1985 (one dollar for one foreign currency). This was done to prevent a country with a high exchange rate per dollar being weighted more heavily than a country with a low exchange rate. The base year of 1985 was chosen arbitrarily.
2) Weighting the exchange rate by the proportion of HRW and WW imported from the U.S. This can be summarized under the following formula:

$$\sum_{i}^{m} q_i \; exr_i/q \;, \tag{36}$$

where:

exr_i = exchange rate for i,

i = country i,

m = the number of countries importing HRW and WW,

q_i = quantity of wheat exported from U.S. to country i,

q = total quantity of HRW and WW exported from the U.S.

3) Applying equation (36) each year to create a time series from 1962 to 1985.

4) The GNP per capita for each wheat classes studied is weighted by the quantity of HRW or WW imported from the U.S., as indicated by equation (37) for HRW:

$$\sum_{i}^{m} q_i \, GNP_i/q \, , \qquad (37)$$

where:

i = country i,

m = the number of countries that import HRW,

GNP_i = GNP per capita for country i,

q_i = quantity of HRW imported from the U.S. by country i, and

q = total quantity of HRW exported from the U.S.

The same operation for (37) is used for WW. We also divide equation (37) by the U.S. CPI. It would be more appropriate to divide the GNP of country i by its own CPI rather than by the U.S. CPI. A lack of available data did not allow this computation to be done.

The exchange rate in the two wheat classes WW and HRW was not divided as done for the GNP; this was due to the double instantaneous causal effect between HRW price and WW price as described in Part 1 of this thesis. This strong relationship between HRW and WW prices suggests that HRW and WW are substitutes. Thus a country like India will readily substitute between these two wheat classes. It would be inconsistent with previous results to use two exchange rates for HRW and WW.

C) Functional form and hypothesis tested

1) Functional form choice

As indicated earlier, there exists a system of three equations by wheat classes. Which is the appropriate form?

A simple linear equation has the advantage of being easy to compute and to analyze but does not compute the coefficient of elasticity. An alternative is to use the following function:

$$q = ap^{\alpha}\phi^{\beta} \ , \tag{38}$$

where:

q = quantity demanded,

p = price,

ϕ = information,

α = coefficient of price estimate,

β = coefficient of ø estimate, and

a = intercept term.

The advantages of using a formulation such as (38) are 1) linear regression is used by taking the log, and 2) the coefficients represent the elasticity of quantity demanded. Because of these advantages, this functional form will be used.

Equation (38) can be transformed as follows:

$$\log(q) = \log(a) + \alpha\log(p) + \beta\log(\phi) \tag{39}$$

This can be directly estimated by using a nonlinear method of regression.

Hendersen and Quandt (1980) give this definition for price elasticity: "the own elasticity of demand for q is defined as the proportionate rate of change of q by the proportionate change of its own price.... (p. 22)":

$$E = - p/q\ \delta q/\delta p = \delta \log(q)/\delta \log(p) , \qquad (40)$$

where:

E = price elasticity.

From (39) and (40) we can write:

$$E = \alpha . \qquad (41)$$

The demand is elastic when the absolute value of α is greater than one (α > 1). This means, for instance, that a 10-percent increase in price gives a higher decrease (if assumed that demand is sloping downward) in q.

The demand is unitary elastic when the absolute value of ã is equal to one (α = 1). This means, for example, that a 10-percent increase in price gives a 10-percent decrease (if assumed that demand is downward sloping) in q.

The demand is inelastic when the absolute value of ã is smaller than one (α < 1). This means that a 10-percent increase in price gives a decrease (if assumed that demand is downward sloping) in q of less than 10 percent.

The demand has no response to a price change when ã is equal 0. This means that a 10-percent increase in price does not provoke a response in q.

2) Hypotheses to test

We want to test whether the coefficients of elasticity are equal or different from zero. When the coefficient of elasticity is equal to zero, a change in explanatory variables will not affect the dependent variable. Following our previous example about price elasticity (equation (40)), the alternative becomes:

$$H_0: \alpha = 0 \text{ and} \quad (42)$$

$$H_1: \alpha \neq 0 . \quad (43)$$

To test such hypotheses, we use the t test where the t computed is:

$$t = \alpha / s_\alpha , \quad (44)$$

where:

s_α = standard deviation of α.

H_0 would be rejected if at the confidence interval of 95 percent or 99 percent, the t statistic given by the table is greater than the t statistic computed by equation (44). We cannot reject the hypothesis if the coefficient of elasticity equals zero.

Following this presentation of the choice of a functional form and hypotheses test, the system of equations will be presented.

3) Domestic demand

i) HRW domestic demand

We consider as a dependent variable the U.S. consumption per capita of HRW (HWDUS). These data are computed by dividing HRW domestic uses with the U.S. population.

The explanatory variables are 1) the deflated U.S. farm price of HRW (HWFPR), 2) the deflated U.S. GNP per capita (GNPUS), and 3) the U.S. consumption of HRW per capita of the previous year (HWDUS1).

The formulation becomes:

$$HWDUS = \alpha_1 \; HWFPR^{\alpha_2} \; GNPUS^{\alpha_3} \; HWDUS1^{\alpha_4} \quad (45)$$

We need to test:

$$H_0: \alpha_i = 0 \text{ and} \tag{46}$$

$$H_1: \alpha_i \neq 0 ; \tag{47}$$

where:

$i = 2...4$.

We expect to find:

- α_2 as a negative value. In the normal case, when the price increases, the wheat demand is expected to fall,
- α_3 as a positive value. When the income increases, the wheat demand is expected to increase, and
- α_4 as a positive value. When the previous demand increases, the current demand is expected to follow the same path.

ii) WW domestic demand

For WW, the same formulation exists as for HRW. The dependent variable is the U.S. consumption per capita of WW (WWDUS).

The explanatory variables are 1) the deflated U.S. farm price of WW (WWFPR), 2) the deflated U.S. GNP per capita (GNPUS), and 3) the U.S. consumption of WW per capita of the previous year (WWDUS1).

The formulation becomes:

$$WWDUS = \beta_1 \; WWFPR^{\beta 2} \; GNPUS^{\beta 3} \; WWDUS^{\beta 4} . \tag{48}$$

The hypotheses tested becomes:

$$H_0: \alpha_i = 0 \text{ and} \tag{49}$$

$$H_1: \alpha_i \neq 0 . \tag{50}$$

We expect to find:

- α_2 as a negative value. In the normal case, when the price increases, the wheat demand is expected to fall,
- α_3 as a positive value. When the income increases, the wheat demand is expected to increase, and
- α_4 as a positive value. When the previous demand increases, the current demand is expected to follow the same path.

4) Foreign demand

The foreign demand for HRW and WW will be considered.

i) HRW foreign demand

The dependent variable is the quantity of HRW exported from the U.S. (HWEXPT).

The explanatory variables are 1) the ratio of the HRW FOB price and the WW FOB price (PRHW) to avoid multicollinearity due to a high rate of substitution between these two wheat classes (see Part 1 of this thesis), 2) the exchange rate (TEXR, see data transformation), 3) the GNP corresponding to the countries that import HRW (GNPHW), 4) the trade dependency ratio, which is the ratio between foreign wheat consumption and foreign wheat production (TDR), and 5) the HRW export of the previous year (HWEXPT1).

The formulation becomes:

$$HWEXPT = \alpha_5\ PRHW^{\alpha 6}\ TEXR^{\alpha 7}\ GNPHW^{\alpha 8}\ TDR^{\alpha 9}\ HWEXPT1^{\alpha 10} . \qquad (51)$$

Similar to the domestic demand, the hypotheses is:

$$H_0:\ \alpha_j = 0 \text{ and} \qquad (52)$$

$$H_1:\ \alpha_j \neq 0 ; \qquad (53)$$

where:

$j = 6 \ldots 10$.

We expect to have:

- α_6 as a negative value. When the price of HRW increases, we expect a decrease in the quantity of HRW exported,
- α_7 as a negative value. When the exchange rate (foreign currency per dollar) increases, the exporting of U.S. products is expected to decrease,
- α_8 as a positive value. When the income increases, we expect an increase in the demand of wheat,
- α_9 as a positive value. When a country becomes more self-sufficient, its imports of wheat are expected to decrease, and
- α_{10} as a positive value. The previous volume exported may positively affect the current export.

ii) WW foreign demand

The formulation of foreign demand for WW is slightly different from HRW.

The dependent variable is the quantity of WW exported from the U.S. (WWEXPT).

The explanatory variables are 1) the ratio of the HRW FOB price and the WW FOB price (PRWW), 2) the CIF price in Japan (RJPR), 3) the exchange rate (TEXR), 4) the GNP corresponding to the countries importing WW (GNPWW), 5) the wheat production in Australia (WAUST), and 5) the WW export of the previous year (WWEXPT1).

The formulation becomes:

$$WWEXPT = \beta_5 \; PRWW^{\beta_6} \; RJPR^{\beta_7} \; TEXR^{\beta_8} \; GNPWW^{\beta_9} \; WAUST^{\beta_{10}} \; WWEXPT1^{\beta_{11}} \quad (54)$$

The hypotheses are:

$$H_0: \beta_j = 0 \text{ and} \quad (55)$$

$$H_1: \beta_j \neq 0 . \quad (56)$$

where:

$j = 6...11$.

We expect to have:

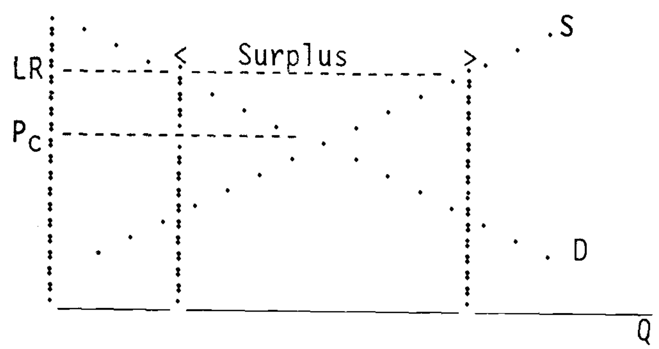
- β_6 as a negative value. When the price of WW increases, we expect a decrease in the quantity of WW exported,
- β_7 as a positive value. When the price of rice increases, we expect an increase in the quantity of WW exported, based on the assumption that rice is a substitute for WW in the Asian market,
- β_8 as a negative value. When the exchange rate (foreign currency per dollar) increases, the export of U.S. products is expected to decrease,
- β_9 as a positive value. When the income increases, we expect an increase in the demand of wheat,
- β_{10} as a negative value. Australia is a competitor of the U.S. in the WW market. An increase in Australian wheat production should decrease the export of WW, and
- β_{11} as a positive value. The previous volume exported may positively affect the current export.

5) Carry-over

The carry-over equation is slightly different from the others. The dependent variable is the ratio between the wheat price and the loan rate. The loan rate can be considered as the minimum price that the farmer expects to receive. At times, the wheat price and loan rate are very close. During the 1980's, this was especially true and the U.S. began to have large unplanned stocks of wheat. In economic theory, surplus (i.e., unplanned stocks) does not exist in perfect competition because supply equals demand. When the government intervenes and fixes the price such as fixing the loan rate above the competitive price, stocks are created.

Figure 3

Stock creation



For this reason the dependent variable is the ratio between wheat price and loan rate.

i) HRW carry-over

As explained above, the dependent variable is the ratio between the farm price of HRW and the loan rate (PRSTH).

The explanatory variables are 1) the ending stock of HRW (HWSTEN), 2) the real interest (IR, interest rate deflated), and 3) the previous price ratio between HRW farm price and the loan rate (PRSTH1).

The real interest rate is negative. Therefore, its log cannot be taken. The formulation becomes:

$$PRSTH = \alpha_{11}\ HWSTEN^{\alpha_{12}}\ PRSTH1^{\alpha_{13}}\ E^{\alpha_{14} IR}, \qquad (57)$$

where:

$E^{\alpha 14 IR}$ = exponential function of the interest rate. Note that α_{14} is not the coefficient of elasticity of the interest rate (see definition above).

The hypotheses become:

$$H_0: \alpha_g = 0 \text{ and} \tag{58}$$

$$H1: \alpha_g \neq 0 ; \tag{59}$$

where:

$g = 12...14$.

We expect to find:

- α_{12} as a negative value. When the stock increases, we expect the price ratio to decrease,
- α_{13} as a positive value. When the previous price ratio increases, we expect to have an increase in current price ratio due mainly to the loan rate which follows a path given by the farm bill, and
- α_{14} as a negative value or a negative value. The cash price is independent of the loan rate and can move above or under the loan rate.

ii) WW carry-over

The formulations are exactly the same for WW as for HRW.

The dependent variable is the ratio between the WW farm price and the loan rate (PRSTW).

The explanatory variables are 1) the ending stock of WW (WWSTEN), 2) the real interest rate (IR, interest rate deflated), and 3) the previous price ratio between WW farm price and the loan rate (PRSTW1).

For the reasons previously explained, the log of the real interest rate cannot be taken. The formulation becomes:

$$PRSTW = \beta_{12}\ WWSTEN^{\beta 13}\ PRSTW1^{\beta 14}\ E^{\beta 15 IR}\ , \qquad (60)$$

where:

$E^{\beta 15IR}$ = exponential function of the interest rate. Note that β_{15} is not the coefficient of elasticity of the interest rate.

The hypotheses become:

$$H_0\colon\ \beta_g = 0 \text{ and} \qquad (61)$$

$$H_1\colon\ \beta_g \neq 0\ , \qquad (62)$$

where:

g = 13...15 .

We expect to find:

- β_{13} as a negative value. When the stock increases, we expect the price ratio to decrease,
- β_{14} as a positive value or negative value for the same reasons that for HRW, and
- β_{15} as a negative value. When the interest rate increases, we expect people to sell their stock, thereby decreasing the price.

6) Identity equation

To conclude our model we need to specify the identity equation. The identity function requires total demand to equal total supply:

$$HWSTBE + HWPROD = HWDUS + HWEXPT + HWSTEN\ , \qquad (63)$$

where:

HWSTBE = HRW stock at the beginning,

HWPROD = HRW production,

HWDUS = HRW U.S. demand,

HWEXPT = HRW foreign demand, and

HWSTEN = HRW stock at the end; and

$$WWSTBE + WWPROD = WWDUS + WWEXPT + WWSTEN, \quad (64)$$

where:

WWSTBE = WW stock at the beginning,

WWPROD = HRW production,

WWDUS = WW U.S. demand,

WWEXPT = WW foreign demand, and

WWSTEN = WW stock at the end.

As we saw earlier, production can be considered, in our model, as an exogenous variable. We also can consider stock at the beginning as an exogenous variable because it is left over from the previous crop year. Therefore, the total supply in the short run is price inelastic and predetermined. For these reasons, we are not going to compute the total supply equations. Instead we will consider the supply side to determine the endogenous and predetermined variables in our system of equations determined above.

D) System of equations

1) HRW

U.S. HRW demand:

$$HWDUS = \alpha_1 \ HWFPR^{\alpha 2} \ GNPUS^{\alpha 3} \ HWDUS1^{\alpha 4} , \quad (45)$$

U.S. HRW foreign demand:

$$HWEXPT = \alpha_5 \ PRHW^{\alpha 6} \ TEXR^{\alpha 7} \ GNPHW^{\alpha 8} \ TDR^{\alpha 9} \ HWEXPT1^{\alpha 10} , \quad (51)$$

HRW carry-over:

$$PRSTH = \alpha_{11}\ HWSTEN^{\alpha_{12}}\ PRSTH1^{\alpha_{13}}\ E^{\alpha_{14} IR}\ , \text{ and} \qquad (57)$$

HRW identity:

$$HWSTBE + HWPROD = HWDUS + HWEXPT + HWSTEN\ ; \qquad (63)$$

the endogenous variables:

HWDUS = U.S. consumption of HRW per capita (bushel/person),

HWEXPT = quantity of HRW exported from U.S. (million bushels),

HWSTEN = ending stock of HRW (million bushels),

HWFPR = HRW farm price deflated (dollar per bushel),

PRHW = ratio between HRW FOB price and WW FOB price,

PRSTH = ratio between HRW farm price and loan rate; and

the predetermined variables:

GNPUS = U.S. GNP per capita deflated (dollar/person),

TEXR = Exchange rate base 1985 for HRW and WW (foreign currencies per dollar),

GNPHW = GNP per capita corresponding to the country imported HRW (dollar/person),

TDR = trade dependency ratio (foreign wheat consumption over foreign wheat production),

IR = Real interest rate,

HWPROD = HRW U.S. production,

HWDUS1 = lag one year of HWDUS,

HWEXPT1 = lag one year of HWEXPT,

HWSTEN1 = lag one year of HWSTEN,

HWFPR1 = lag one year of HWFPR,

PRHW1 = lag one year of PRHW, and

PRSTH1 = lag one year of PRSTH.

2) **WW**

U.S. WW demand:

$$WWDUS = \beta_1\ WWFPR^{\beta 2}\ GNPUS^{\beta 3}\ WWDUS^{\beta 4}\ , \tag{48}$$

U.S. WW foreign demand:

$$WWEXPT = \beta_5\ PRWW^{\beta 6}\ RJPR^{\beta 7}\ TEXR^{\beta 8}\ GNPWW^{\beta 9}\ WAUST^{\beta 10}\ WWEXPT1^{\beta 11}\ , \tag{54}$$

WW carry-over:

$$PRSTW = \beta_{12}\ WWSTEN^{\beta 13}\ PRSTW1^{\beta 14}\ E^{\beta 15 IR}\ , \text{ and} \tag{60}$$

WW identity:

$$HWSTBE + HWPROD = HWDUS + HWEXPT + HWSTEN\ ; \tag{64}$$

The endogenous variables:

WWDUS = U.S. consumption of WW per capita (bushel/person),

WWEXPT = quantity of WW exported from U.S. (million bushels),

WWSTEN = ending stock of WW (million bushels),

WWFPR = WW farm price deflated (dollar/bushel),

PRWW = ratio between WW FOB price and HRW FOB price,

PRSTW = ratio between WW farm price and loan rate, and

RJPR = price rice CIF Japan (dollar/metric tons); and

the predetermined variables:

GNPUS = U.S. GNP per capita deflated (dollar/person),

TEXR = exchange rate base 1985 for HRW and WW (foreign currencies per dollar),

GNPWW = GNP per capita corresponding to the countries imported WW (dollar/person),

TDR = trade dependency ratio (foreign wheat consumption over foreign wheat production),

IR = real interest rate,

WWPROD = WW U.S. production,

WWDUS1 = lag one year of WWDUS,

WWEXPT1 = lag one year of WWEXPT,

WWSTEN = lag one year of WWSTEN,

WWFPR1 = lag one year of WWFPR,

PRWW1 = lag one year of PRWW,

RJPR1 = lag one year of RJPR, and

PRSTW1 = lag one year of PRSTW.

All the predetermined variables are used as instrumental variables. The system of equations is overidentified, meaning that the number of predetermined variables is greater than the number of endogenous variables. It is called, in econometrics, the order condition, which is a necessary but not sufficient condition. A system of equation can be estimated only if the number of predetermined variables excluded from the equation is at least equal to the number of endogenous variables included on the right-hand side of the equation. 3SLS will estimate simultaneously the system of equation for HRW and for WW.

3-3) RESULTS

To estimate the system of equations, TSP (Time Series Processor) version 4.0 is used. The results give 1) the coefficients of the explanatory variables, 2) the standard deviations of the coefficients of the explanatory variables, 3) the t statistic, 4) the level of significance (* significant at the 10-percent level, ** significant at the five-percent level, *** significant at the one-percent level), and 5) the Durbin Watson (DW) statistic.

A) Domestic Demand

1) U.S. demand for HRW

The HRW domestic demand equation has been determined earlier (equation (45)). The dependent variable is the U.S. consumption of HRW per capita (HWDUS). The results are as follows:

Table 1

U.S. demand for HRW

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	0.274	0.957	0.272		1.722
HWFPR	-0.335	0.159	2.099	**	
GNPUS	-0.134	0.119	1.134		
HWDUS1	0.396	0.151	2.612	**	

At the 10-percent level, the t statistic given by table 1 for 19 degrees of freedom is 1.729. At this level, the null hypothesis defined by equation (51) for HWFPR and HWDUS1 is rejected. The coefficient for GNPUS has the wrong sing but is not significantly different from zero.

At the five-percent level, the t statistic given by the table with 19 degrees of freedom is 2.093. Thus, the coefficients of HWFPR and HWDUS1 are significantly different from zero; all other coefficients are not significantly different from zero. These results mean 1) for a one-percent increase in HRW farm price, the U.S. demand for HRW decreases by 0.335 percent (0.335 is the coefficient of price elasticity); 2) for a one-percent increase in the previous U.S. demand for HRW, the current U.S. demand for HRW increases by 0.396 percent; and 3) for a one-percent increase in U.S. GNP per capita, the U.S. demand for HRW does not show an increase or a decrease.

The main factor in the model determining the U.S. demand for HRW is the previous U.S. demand for HRW and the farm price of HRW. The coefficient of the U.S. GNP per capita is neither significant from zero at 10 percent nor at five percent. The coefficient of price elasticity is different from that estimated by Chai (1967), but it is more similar than those estimated by Kahlon (1961).

In the introduction, we defined internal and external information. Internal information is information given by the wheat class such as price or market characteristics, external information is information that is independent of the wheat class, such as consumer income. Normally, all the endogenous and the lag of endogenous variables constitute internal information, while all exogenous variables constitute external information. HWDUS1 and HWFPR are two forms of internal information. The influence of HWDUS1 on HWDUS is explained by HRW market characteristics such as the need for high protein content and a continuity in output (e.g., flour). HWFPR, depending on the supply and demand for HRW, is by definition internal.

2) U.S. demand for WW

The WW domestic demand equation was determined earlier by equation (48). The dependent variable is the U.S. consumption of WW per capita (WWDUS). The results are as follows:

Table 2

U.S. demand for WW

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	0.035	1.041	0.034		1.898
WWFPR	-0.276	0.171	1.618		
GNPUS	-0.182	0.125	1.456		
WWDUS1	0.521	0.127	4.082	***	

At the 10-percent level, the t statistic for 19 degrees of freedom is 1.729. At this level, the null hypothesis defined by equation (49) is rejected for WWDUS1. Otherwise, the null hypothesis cannot be rejected for WWFPR and GNPUS. These results mean 1) for a one-percent increase in the previous demand for WW, U.S. demand for WW increases by 0.521 percent; 2) for a one-percent increase in the WW farm price, the U.S. demand for WW does not show an increase or a decrease; and 3) for a one-percent increase in the U.S. GNP per capita, the U.S. demand for WW does not show an increase or a decrease.

At the one-percent level, the t statistic given by the table for 19 degrees of freedom is 2.861. At this level, just the coefficient of WWDUS1 is significant, all other coefficients are not significantly different from zero.

The mail factor in the model determining the U.S. demand for WW is the previous U.S. demand for WW. This coefficient is highly significant even at the one-percent level. All other coefficients are not significant from zero even at the 10-percent level. The demand is price inelastic. The price elasticity for WW is similar to that estimated by Chai Ju Chun; Kahlon did not compute the price elasticity for WW.

Just as for HRW, the lag of domestic demand for WW is international information. The influence of WWDUS1 on WWDUS can be explained by WW market characteristics, such as the need for low protein content for some special uses, a high extraction yield, and a continuity in output. For some of these reasons, the consumer is willing to use WW rather than another wheat class.

B) Foreign Demand

1) Foreign demand for U.S. HRW

The HRW foreign demand equation was determined earlier by equation (5). The dependent variable is the HRW quantity exported from the U.S. (HWEXPT). The results are shown on table (3):

Table 3

Foreign demand for U.S. HRW

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	2.449	1.471	1.665		2.24
PRHW	-0.104	0.889	0.117		
GNPHW	-0.129	0.139	0.923		
TEXR	-0.361	0.276	1.305		
TDR	2.107	0.867	2.430	**	
HWEXPT1	0.728	0.157	4.620	***	

At the 10-percent level, the t statistic given by the table for 17 degrees of freedom is 1.740. At this level, the null hypothesis defined by equation (52) for TDR and HWEXPT1 can be rejected. Otherwise, the null hypothesis cannot be rejected for PRHW, GNPHW, TEXR, TDR. These results mean 1) for a one-percent increase in the previous foreign demand for U.S. HRW, the current foreign demand for U.S. HRW increases by 0.728 percent; 2) for a one-percent increase in TDR, the current foreign demand for U.S. HRW increases by 2.107 percent; and 3) for a one-percent increase in one of the other explanatory variables, the current foreign demand for U.S. HRW does not show an increase or a decrease.

At the five-percent level, TDR and HWEXPT1 are still significantly different from zero. At the one-percent level, only the coefficient of HWEXPT1 is highly significant.

The main factors in the model determining foreign demand for U.S. HRW are the previous foreign demand for U.S. HRW and the TDR. Also, since the demand is not price elastic, the null hypothesis for the coefficient of the ratio between HRW FOB price and WW FOB price cannot be rejected.

HWEXPT1 is an internal information while TDR is an external information. The influence of HWEXPT1 on HWEXPT is explained by HRW foreign market characteristics, such as the need for high protein and by the willingness of the U.S. to keep a world wheat market share. HRW export statistics show important support from the U.S. government, such as PL 480 and EEP (Export Enhancement Program). The nonsignificance of price and exchange rate reinforce this point. Price and exchange rate are overwhelmed by more important criteria, such as the governmental donation of credit to another government in exchange for buying U.S. wheat. Government programs are conducted to negate a relatively high internal prices and to deliver wheat at the import countries at the best competitive conditions, such as line of credit or payment conditions. TDR depends on foreign wheat consumption and the foreign wheat production. Just foreign wheat consumption is dependent for a small part of U.S. wheat supply. Other more important factors influence wheat consumption. For these reasons, TDR is considered to be external information regarding HRW.

The results for HRW domestic demand and foreign demand are as expected. The HRW main market is the U.S. market; the leftovers are exported under governmental programs.

2) Foreign demand for U.S. WW

WW foreign demand was determined earlier in equation (54). The dependent variable is the quantity of WW exported from the U.S. (WWEXPT). The results are shown on table 4:

Table 4

Foreign demand for U.S. WW

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	2.080	0.892	2.332		2.146
PRWW	0.407	0.762	0.534		
RJPR	0.382	0.117	3.258	***	
GNPWW	0.239	0.066	3.605	***	
TEXR	-0.175	0.280	0.626		
WAUST	-0.079	0.129	0.614		
WWEXPT1	0.061	0.218	0.281		

At the 10-percent level, the t statistic for 16 degrees of freedom is 1.746, at the five-percent level, the t statistic for 16 degrees of freedom is 2.120, and, at the one-percent level, the t statistic given by the table for 16 degrees of freedom is 2.921. At all these levels, the null hypothesis, as defined by equation (55) for RJPR and GNPWW can be rejected. The null hypothesis for PRWW, TEXR, WAUST, WWEXPT1, cannot be rejected at the 10-percent level. These results mean 1) for a one-percent increase in the rice CIF price in Japan, the foreign demand for U.S. WW increased by 0.382

percent; 2) for a one-percent increase in the GNP per capita for countries importing WW, the foreign demand for U.S. WW increases by 0.239 percent; and 3) for one-percent increase in one of the other explanatory variables, the current foreign demand for U.S. WW does not show an increase or a decrease.

The hypothesis that rice is a substitute for WW seems to be true, according to results given in table (4). The hypothesis that wheat production in Australia is an important factor in determining WW demand, is less plausible. Once more, the price is not a significant factor.

The main factors determining foreign demand for U.S. WW are the rice CIF price in Japan and the GNP per capita of the countries importing WW.

RJPR is internal information for WW. Rice and WW are supposed to be substitutes and, therefore, compete against each other in the Asian market. GNPWW constitutes an external information for WW. The increase of GNP in countries that import WW depends on criteria such as policy stability. Countries that import WW are those with sizeable augmentation of income during the last decade (Japan, South-Korea, India). The price and exchange rates are also insignificant. This can be explained by the fact that the two main wheat importers (Japan and South Korea) are cash buyers and buy WW on regular basis with little price consideration. The results for WW domestic demand and foreign demand are as expected.

C) Carry-over

1) Carry-over for HRW

The HRW carry-over equation was determined earlier by equation (57). The dependent variable is the ratio between the HRW farm price and the U.S. loan rate (PRSTH). The results are shown below.

Table 5

HRW U.S. carry-over

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	1.231	0.383	3.213		1.597
HWSTEN	-0.193	0.063	3.073	***	
PRSTH1	0.695	0.117	5.940	***	
IR*	0.005	0.018	0.292		

IR*: the coefficient of IR is not the coefficient of elasticity

At the 10-percent level, the t statistic for 19 degrees of freedom is 1.729. At this level, the null hypothesis defined by equation (58) cannot be rejected for IR. All other coefficients are significant even at the one-percent level (t statistic is 2.861). This means 1) for a one-percent increase in the ending stock, the ratio between the HRW farm price and the U.S. loan rate decreases by 0.193 percent; and 2) for a one-percent increase in the previous ratio between the HRW farm price and the U.S. loan rate, the current ratio increases by 0.695 percent. The value of PRSTH can be increased by an increase in the HRW farm price or by a decrease in the U.S. loan rate.

The main factors in the model, determining the ratio between the HRW farm price and the U.S. loan rate, are the ending stocks and the lag of the ratio between the HRW farm price and the U.S. loan rate. The interest rate is not significantly variable enough to explain the carry-over rate.

HWSTEN and PRSTH1 are both internal information (i.e., endogenous variable and lag of the dependent variable). If the ending stock increases, the farm price decreases and therefore, the ratio between HRW farm price and the U.S. loan rate decreases. The significance of the previous price ratio (PSTH1) is more difficult to explain. The change in this ratio can be achieved by a change in the cash price or by a change in the loan rate. The cash price responds to the market change, such as an expected shortage in supply provoked by a drought, while the loan rate is fixed by the U.S. government under the specification given every five years by the farm bill. This suggests that the cash price is independent of the loan rate and, when the lagged ratio moves due to a change in its components, the current ratio moves in the same way with less amplitude due to an inelastic coefficient. These HRW results are as expected.

2) WW carry-over

The WW carry-over equation was determined earlier in equation (60). The dependent variable is the ratio between the WW farm price and the U.S. loan rate (PRSTW). The results are shown below.

Table 6

WW U.S. carry-over

	Coef.	Stand. of dev.	t stat.	Sign.	DW
C	0.232	0.161	1.435		1.534
WWSTEN	-0.034	0.042	0.810		
PRSTW1	0.721	0.157	4.600	***	
IR*	-0.007	0.027	0.272		

IR*: the coefficient of IR is not the coefficient of elasticity

At the 10-percent level, the t statistic for 19 degrees of freedom is 1.729. At this level, the coefficients of HWSTEN and IR are insignificant, the null hypothesis equation (61) cannot be rejected. At the one-percent level, the coefficient of PRSTW1 is still significant. These results mean that for a one-percent increase in the previous ratio between the WW price and the U.S. loan rate, the current ratio increases by 0.527.

The main factor in the model determining the ratio between the farm price of WW and the U.S. loan rate is the previous ratio between the farm price of WW and the U.S. loan rate. Surprisingly, the ending stock is not an important factor in explaining the ratio between the WW farm price and the U.S. loan rate. As for HRW, this result suggests that the cash price is independent of the loan rate and, when the lagged ratio moves due to a change in its components, the current ratio moves in the same way with less amplitude due to an inelastic coefficient.

3-4) CONCLUSION

Part 3 of this dissertation defined the different factors that can explain the U.S. demand per capita, the foreign demand, and the carry-over for U.S. HRW and U.S. WW.

The U.S. demand per capita for HRW can be explained by the HRW farm price (price elasticity of -0.345) and the previous U.S. demand per capita for HRW (elasticity of 0.478). The U.S. income (GNPUS) is not a significant variable.

The U.S. demand per capita for WW can be explained by only the previous demand per capita for WW (elasticity of 0.614). The demand is price inelastic for WW. The relative difficulty of explaining the U.S. demand for WW comes from the fact that WW is mainly sold on the international market (in 1986, only 36 percent of the WW market was U.S. market), while HRW mainly sold on the U.S. market (57 percent).

The foreign demand for HRW can be explained by the previous foreign demand for HRW (elasticity of 0.668) and by the trade dependency ratio. The demand is price inelastic. The lack of information concerning foreign demand for HRW is explained by the fact that this wheat class has an important U.S. market. The surplus is exported under government programs such as PL 480 and the EEP. This model was not able to detect this influence, however.

The foreign demand for WW can be explained by the rice price CIF Japan (elasticity: 0.341) and by the GNP per capita of countries importing WW (0.217). The hypothesis that rice is a substitute for WW in the Asian market is confirmed. An increase in income of Asian countries also affects the demand for U.S. WW. This last point can play an important role. Asian countries have shown significant increase in their income during the last decade. Increased income may be important source of additional sales in the next decade. The coefficient of price ratio is not significantly different from zero.

The HRW carry-over equation has, as the dependent variable, the ratio between the HRW farm price and the U.S. loan rate. This ratio can be explained by the ending stock (elasticity of -0.334) and by the previous ratio between the HRW farm price and the U.S. loan rate (elasticity of 0.602).

The WW carry-over equation has, as the dependent variable, the ratio between the WW farm price and the U.S. loan rate. This ratio can be explained by the previous ratio between the WW farm price and the U.S. loan rate (elasticity of 0.527). Surprisingly, the ending stock is not a significant variable in this equation.

The results were as expected, except for the prices. All prices are not significantly different from zero except in the HRW domestic demand equation. The HRW domestic demand and the WW foreign demand are two interesting equations due to the significance of some coefficients of explanatory variables different from the lag of the dependent variable. These results are due to the fact that HRW is more oriented to the domestic market, while WW is more oriented to the foreign market.

These results show some differences between these two wheats. The objective of Part 4 is to further describe these differences.

PART 4

COMPARISON OF HARD RED WINTER AND WHITE WHEAT

Part 3 determined the structural demand for HRW and WW. In Part 4, the results will be compared to determine the differences and/or similarities between HRW demand and WW demand, and the variables which explain these differences, if any.

4-1) PREVIOUS WORK

Bale and Ryan (1977) studied the effect of wheat protein content on price ratio. The objective of their article was to detect the presence or absence of "protein premium." HRS and HRW were selected to represent, respectively, the high and the low protein wheat of the model. The price ratio is preferred as dependent variable other than price differential to avoid price deflation. OLS was used and the data cover crop years from 1965 to 1975. They concluded that "Four supply variables can be employed in a simple formulation to estimate changes in relative prices of wheats with different protein content. Protein supplies in the HRS crop were more closely related with changes in HRS/HRW price ratios than protein supplies in the HRW crop. (p. 532)"

In the same kind of studies, Wilson (1983) studied the price relationships between HRS and HRW. The dependent variable was the price differential between HRS and HRW. The explanatory variables were the price of HRW, per capita income, total supply of HRS, and average crop protein content for HRS and HRW. The model was estimated for the period, 1962-1982, by the OLS estimators. Their conclusions were: "Price relationships between HRS and HRW are largely explainable by fundamental market phenomena. Particularly important are the size of the HRS crop plus carry over in stocks, and the average protein percentage in the HRW crop. The crop average protein in the HRS crop does not significantly affect prices for HRS or HRW. (p. 19)"

For other commodities, Buccola and Jessee (1979) studied price differentials in feeder steer-heifer. The methodology consisted of determining the demand for feeder steers and for heifers; they used the supply and demand differential and a market clearing identity to derive the reduced form which gave the price differential as dependent variables. The results "provide preliminary evidence on the efficiency with which feeder markets establish price spreads. (p. 61)"

Strohmaier and Dahl (1985) studied price relationships between wheat future markets (Minneapolis,Chicago, and Kansas City). The data cover the period of crop year from 1974 to 1983. The regression model is defined as follows:

$$P_i/P_j = F[BS_i/BS_j, PR_i/PR_j, TSi/TSj, DU_i/DUj, X_i/X_j, TD_i/TD_j, ES_i/ES_j, USR_i/USR_j];$$

where:

i = wheat class i,

j = wheat class j,

P = futures price,

BS = beginning stocks,

PR = production,

TS = total supply,

DU = domestic utilization,

X = export,

TD = total demand,

ES = ending stock, and

USSR = total utilization/total supply.

The study concluded that the "Ratio of fundamental factors of supply and demand for individual classes of wheat are closely associated with changes in relative prices between the three futures markets. (p. 291)"

To compare two commodities, most studies use price ratio or differential as the dependent variable. This is a fast and efficient way as suggested by the studies listed above (i.e., just one equation needs to be determined). Because Part 3 determined the structural demand equation for HRW and WW, the approach used here will be to dually compare the coefficients of HRW and WW.

4-2) METHODOLOGY

Part 3 defined the structural demand equation for HRW and WW. HRW U.S. demand and HRW carry-over have exactly the same form as WW U.S. demand and WW carry-over. The structural differences come from the foreign demand where HRW has, in addition to WW, the TDR, and WW in addition to HRW, the rice price in Japan and the wheat production in Australia. These three explanatory variables are the first differences between HRW and WW.

Further, the objective is to know if the coefficients of elasticities between HRW and WW are the same or not.

For the purpose of testing, one of the three following tests can be used: 1) the likelihood ratio test (LR, used in Part 1 of this research), 2) the Lagrangian multiplier test (LM), and 3) the Wald test (W).

The mathematical formulas are:

$$LR = 2[L(\hat{\delta}) - L(\delta_0)] ,$$

$$LM = S(\delta_0)'[I(\delta_0)]^{-1}S(\delta_0) , \text{ and}$$

$$W = (\hat{\delta}-\delta_0)'I(\hat{\delta})(\hat{\delta}-\delta_0) ;$$

where:

$\hat{\delta}$ = estimators of the unrestricted model,

δ_0 = estimators of the restricted model,

$L(\delta)$ = value of the log of likelihood for the estimate δ,

$I(\delta)$ = information matrix, in this project, it is the covariance matrix obtained after 2SLS, and

$S(\delta)$ = derivation of the log of likelihood ratio with respect to δ.

All these three statistical tests are X^2 distributed with the number of restriction being the degrees of freedom.

Asymptotically all these three tests have the same asymptotic distribution and have the same power (Kmenta, 1986). W involves only unrestricted estimates, LM involves only restricted estimates and LR involves both. In small samples, the tests have different properties only when the restrictions are linear:

$$W > LR > LM .$$

The rejection of the null hypothesis can be favored by using LM while acceptance of the null hypothesis can be favored by using W. In other words, the Wald test is most conservative and allows less type 1 error. A type 1 error occurs when one rejects a true hypothesis.

The null hypothesis (H_0) consists of equating the coefficients of HRW demand with corresponding ones of WW demand. The alternative hypothesis (H_1), by opposition to the null hypothesis, is that at least one of the coefficients of HRW is different from WW.

The methodology consists of:

1) testing the two systems of equations jointly to detect the difference or similarity between HRW and WW demand,
2) in case of a difference between the two systems of equations, testing equation by equation, and
3) in case of a difference of the same type of equations for HRW and WW, testing coefficient by coefficient.

4-3) PRESENTATION OF HYPOTHESES AND RESULTS

A) Joint test for all the equations in the system

The hypotheses are:

$$H_0 = \alpha_2 = \beta_2,\ \alpha_3 = \beta_3,\ \alpha_4 = \beta_4,\ \alpha_6 = \beta_6,\ \alpha_7 = \beta_8,\ \alpha_8 = \beta_9,\ \alpha_{10} = \beta_{11},\ \alpha_{12} = \beta_{13},\ \alpha_{13} = \beta_{14},\ \alpha_{14} = \beta_{15}; \quad (65)$$

H_1: at least one of the α coefficients is different from its β vis-a-vis. (66)

The value given by the computer for W is 21.74 for 10 degrees of freedom. At five percent, the table give a X^2 of 18.307 and, the null hypothesis (H_0) can be rejected. At least one of the coefficients of HRW is different from WW. At the one-percent level, the X^2 given by the table is 23.309 and, the null hypothesis cannot be rejected.

These results mean that at least one of the coefficients of HRW is slight different from WW. Therefore, the question is which set of equations can explain this difference.

B) U.S. demand equation

The hypotheses to test are:

$$H_0: \alpha_2 = \beta_2, \alpha_3 = \beta_3, \alpha_4 = \beta_4 \text{ and} \quad (67)$$

$$H_1: \text{at least one of the } \tilde{a} \text{ coefficients is different from its } \beta \text{ vis-a-vis.} \quad (68)$$

The value given by the computer for W is 1.58 for three degrees of freedom. At five percent, the table gives X^2 of 7.81 and, the null hypothesis (H_0) cannot be rejected. In other words, the distinction between the coefficients of HRW and WW U.S. demand cannot be made.

C) Foreign demand equation

The hypotheses to test are:

$$H_0: \alpha_6 = \beta_6, \alpha_7 = \beta_8, \alpha_8 = \beta_9, \alpha_{10} = \beta_{11} \text{ and} \quad (69)$$

$$H_1: \text{at least one of the } \alpha \text{ coefficients is different from its corresponding } \beta. \quad (70)$$

The value given by the computer for W is 12.082 for four degrees of freedom. At five percent, the table gives a X^2 of 9.488 and, the null hypothesis (H_0) can be rejected. At least one of the $\tilde{a}$ coefficients can be considered different from its corresponding β. The next step is to test each of the coefficients of HRW and WW foreign demand to determine if they are the same:

$$H_0: \alpha_6 = \beta_6 \text{ and} \quad (71)$$

$$H_1: \alpha_6 \neq \beta_6 \ . \tag{72}$$

The value given by the computer for W is 0.137 for one degree of freedom. At five percent, the table gives a X^2 of 3.841 and, the null hypothesis (H_0) cannot be rejected. The coefficient of the ratio between HRW FOB price and WW FOB price for HRW (PRSTH) cannot be considered significantly different from the coefficient of the ratio between WW FOB price and HRW FOB price for WW:

$$H_0: \alpha_7 = \beta_8 \text{ and} \tag{73}$$

$$H_1: \alpha_7 \neq \beta_8 \ . \tag{74}$$

The value given by the computer for W is 0.352 for one degree of freedom. At five percent, the table gives a X^2 of 3.841 and, the null hypothesis (H_0) cannot be rejected. The exchange rate coefficient which is also the exchange rate elasticity for HRW (TEXR) cannot be considered different from the exchange rate elasticity of WW (TEXR):

$$H_0: \alpha_8 = \beta_9 \text{ and} \tag{75}$$

$$H_1: \alpha_8 \neq \beta_9 \ . \tag{76}$$

The value given by the computer for W is 5.902 for one degree of freedom. At five percent, the table gives a X^2 of 3.841 and the null hypothesis (H_0) can be rejected. The income elasticity for HRW (GNPHW) can be considered different from the income elasticity of WW (GNPWW). At one percent, the X^2 is 6.635 and the null hypothesis cannot be rejected. Therefore, the income elasticity is slightly different between HRW and WW:

$$H_0: \alpha_{10} = \beta_{11} \text{ and} \tag{77}$$

$$H_1: \alpha_{10} \neq \beta_{11} \ . \tag{78}$$

The value given by the computer for W is 6.588 for one degree of freedom. At five percent, the table gives a X^2 of 3.841 and, at one percent, a X^2 of 6.635 and, in both cases, the null hypothesis can be rejected. The previous foreign demand elasticity for HRW (HWEXPT1) can be considered different from the previous foreign demand elasticity for WW (WWEXPT1).

The coefficients of HRW foreign demand are different from the coefficients of WW foreign demand. This difference is due to the income elasticity and previous foreign demand elasticity. The price of rice in Japan (RJPR) and the wheat production in Australia (WAUST) are other variables that differ from WW to HRW and the trade dependency ratio (TDR) differs from HRW and WW. RJPR and WAUST are not explanatory variables for HRW, while TDR is not an explanatory variable for WW. Two of these three explanatory variables are different from zero; TDR and RJPR, while WAUST is not significantly different from zero.

D) The carry-over equation

The hypotheses to test are:

$$H_0: \alpha_{12} = \beta_{13}, \alpha_{13} = \beta_{14}, \alpha_{14} = \beta_{15} \text{ and} \qquad (79)$$

H_1: at least one of the α coefficients is different from its vis-a-vis. (80)

The value given by the computer for W is 7.551 for three degrees of freedom. At five percent, the table gives a X^2 of 7.815 and, the null hypothesis (H_0) cannot be rejected. The distinction between the coefficients of HRW and WW carry-over cannot be made. The carry-over equation for HRW and WW cannot explain the distinction between HRW coefficients and WW coefficients detected previously.

4-4) CONCLUSION

The first difference between HRW and WW derived demand is the specification of the systems of equations. HRW foreign demand and WW foreign demand do not have the same specification. The trade dependency ratio (TDR) is an explanatory variable for HRW and not for WW, while the price of rice in Japan (RJPR) and wheat Australian production (WAUST) are explanatory variables for WW and not for HRW. TDR and RJPR are significant variables at the one-percent level, while WAUST is not significantly different from zero even at the 10-percent level.

Besides the difference in specification, the objective is to know if the coefficients for HRW demand are different or similar to its corresponding coefficients for WW.

A joint test shows that, at the five-percent level, the null hypothesis can be rejected, while at 10 percent it cannot be rejected. This means, there is difference between HRW and WW demand at five percent.

When the same test is applied, equation by equation, the null hypothesis cannot be rejected for U.S. WW and HRW domestic demand and carry-over, while it can be rejected for the U.S. HRW and WW foreign demand equation.

Investigating further, the Wald test shows that this difference comes from the income elasticity and from the previous demand elasticity.

PART 5

CONCLUSIONS

The three main objectives of this thesis were 1) to develop a model to analyze causality between HRW and WW prices; 2) to determine factors affecting the demand for HRW and WW; and 3) to determine the difference between the explanatory variable coefficients of HRW and WW.

5-1) CAUSALITY

As shown in Part 2 of this thesis, using monthly average cash and daily FOB (gulf of Mexico and Portland) prices, the HRW price instantaneously causes the WW price and the WW price instantaneously causes the HRW price. In other words, a feedback relationship exits. For time periods greater than one month, no relationship was detected. For a time period of one week, the HRW price causes the WW price with a low level of significance, but there is no feedback, (i.e., the WW price does not cause the HRW price). Therefore, the joint causal relationship between HRW and WW prices seems to be within in a day period. Over a period that is more than one day but less than one month, HRW price causes WW price. This strong relationship between the HRW and WW prices implies that HRW and WW are close substitutes.

5-2) DETERMINATION OF THE DERIVED DEMAND

Part 3 of this thesis identified factors that explain the U.S. demand per capita, the foreign demand, and the carry-over for U.S. HRW and WW. These factors may be summarized as follows:

1) The U.S. demand per capita for HRW is explained by the HRW farm price and the lagged demand per capita.

2) The U.S. demand per capita for WW is explained by the lagged demand per capita.

3) The foreign demand for HRW is explained by the lagged foreign demand for HRW and by the trade dependency ratio (the ratio of foreign consumption to foreign production).

4) The foreign demand for WW is explained by the CIF Japan rice price and by the GNP per capita of countries importing WW.

5) The HRW carry-over equation has, as a dependent variable, the ratio between the HRW farm price and the U.S. loan rate. This ratio is explained by the ending stock and by the previous ratio between HRW farm price and the U.S. loan rate.

6) The WW carry-over equation has, as a dependent variable, the ratio between the WW farm price and the U.S. loan rate.

7) Except for HRW domestic demand, all the coefficients of price elasticity were not significantly different from zero. Therefore, factors other than price appear to determine the quantity of HRW and WW demanded.

5-3) DEMAND COMPARISON BETWEEN HRW AND WW

The first dissimilarity between HRW and WW demand is the foreign demand equation specification. The trade dependency ratio is an explanatory variable for HRW and not for WW, while the price of rice in Japan and wheat Australian production are explanatory variables for WW and not for HRW.

The comparison of all the HRW coefficients with their corresponding WW coefficients shows that, at five percent, HRW demand has at least one coefficient that differs from its WW counterpart. In the foreign demand equations, the coefficients of income and previous foreign demand (lag one year) are different for HRW and WW. Therefore, HRW and WW foreign demand equations explain the dissimilarity between HRW and WW coefficients; in the other equations (U.S. demand and carry-over), the coefficients of HRW and WW cannot be considered different from each other.

5-4) IMPLICATIONS

A) Implications for HRW

The various results show that the price, the trade dependency ratio, and the previous demand are the most important factors that explain HRW demand. Five main implications are treated in the following paragraphs.

An increase in domestic demand for HRW could be achieved by decreasing the domestic price; however, due to its inelastic coefficient (0.335), the total revenue would then also decrease. The policy of the U.S. government, through the Food Security Act of 1985, is to lower the loan rate. There are two possible results: 1) the HRW price would not be affected if the competitive price is above the loan rate or 2) the HRW price would drop if the competitive price was below the loan rate. The sizeable amount of stocks shows that the competitive price is below the loan rate. Therefore, the U.S. policy would lead to a drop in the HRW price and in the farm revenue. The positive effect would be a reduction of HRW stocks.

Some difficulty may be experienced for HRW foreign demand as a result of a possible decrease in the trade dependency ratio (ratio between foreign wheat consumption and foreign wheat production). Most countries try to be self-sufficient for their fundamental foods such as wheat. The most successful example is the European Economic Community (EEC), which was one of the most important world wheat importers but is now the world's second largest wheat exporter. On the other hand, an unsuccessful example is the USSR which increased its trade dependency ratio. Now, the USSR is the leading world wheat importer. Overall, the world trade dependency ratio is expected to decrease, therefore, harming exports of HRW.

An increase in the current domestic demand will provoke an increase in the future HRW domestic demand. This implies that sales promotion of HRW will stimulate the future HRW demand. This statement is true for the U.S. HRW domestic demand, and for the foreign HRW demand. The objective of a sale promotion program should be to increase the wheat demand at time t, knowing that at t+1 a multiplication effect will further increase the quantity demanded. To be economically successful, the cost of the sale promotion, at time t, must be inferior or at least equal to the discounted stream of gain over the period time t+1, where i goes from 1 to infinity. This means that the present value of the return of the investment must at least be equal or superior to the initial value of the investment. A decrease of HRW price provokes, immediately, an increase in the demand but the revenue lost will take a long time to be compensated due to very low coefficients of elasticity for price and previous demand. A promotion sale, oriented to an opening of credit such as done under the EEP, could have a positive effect, if it is followed by a policy of better understanding of the product quality. Therefore, a good sale promotion should be oriented to better HRW uses, a better HRW market positioning, new HRW uses, and new products from HRW.

The U.S. GNP coefficient for HRW comes with a negative sign but it cannot be considered significantly different from zero. Therefore HRW is not a normal good, and is almost an inferior good for the U.S. market. A market repositioning is needed to replace HRW from an inferior good to at least a normal good (coefficient with a positive sign). This can be done by repositioning HRW, and by developing new HRW uses or new products from HRW.

The last implication concerns the causality effect between HRW and WW. The strong relationships between the HRW and the WW prices show that the two prices are not independent. Thus, a movement of WW prices due to a shift in supply or demand will instantaneously provoke a reaction in the HRW prices.

B) Implications for WW

The foreign GNP per capita, the CIF Japan price, and the previous demand are the most important factors in explaining WW demand. Five main implications are discussed in the following paragraphs.

An increase in the WW foreign demand is possible due to an increase in the GNP per capita of the Pacific Rim countries (the most important WW buyers). For instance, Japan and South Korea regularly account for almost 50 percent of U.S. WW exports. Production growth is forecasted for these countries, and WW foreign demand will increase as a result.

A drop in the rice price will reduce U.S. WW foreign demand. On the other hand, an increase in the rice price will increase this demand. Rice is a major substitute for WW in the Pacific Rim countries. The World Bank forecasts an increase in the rice price in the Asian countries until 1995 (The World Bank, Annual Report 1987, p 91). If this forecast is true, the foreign demand for WW will increase. Also, the politics of dumping the rice price has a negative effect on WW foreign demand; and, therefore, harms the WW farmer. Wheat farmers should lobby to avoid political actions which provoke a dumping of the rice price.

A drop in the HRW price will induce an instantaneous drop in the WW price. On the other hand, a shortage in the HRW supply due to drought, for example, will increase the HRW price and also the WW price due to the strong relationship between the HRW and the WW prices. As we have seen, this means that a movement of HRW due to a shift of the supply or the demand curves will instantaneously provoke a reaction on the WW prices.

An increase in the current domestic and the foreign demand for WW will provoke an increase in the future WW demand. This implies that WW needs to increase its current market penetration in order to increase its future demand. Increased sales promotion will stimulate the WW demand. For HRW, this sales promotion should not be oriented to a decrease in the WW price, but instead should focus on better WW uses, a better WW market positioning, new WW uses, and new products from WW.

For HRW, the U.S. GNP coefficient for WW comes with a negative sign but it cannot be considered differently significant from zero. Therefore, WW is not a normal good and is almost an inferior good for the U.S. market. A market repositioning is needed to replace WW from an inferior good to at least a normal good (coefficient with a positive sign). This can be done by repositioning HRW, and by developing new WW uses or new products from WW.

C) Implications for Oregon

In the case of an increase in the WW foreign demand due to an increase in the Pacific Rim countries income and an increase in the rice price, Oregon, due to its geographical location, may use this opportunity to increase its WW export. Before an increase in production, stock may decrease.

If the government continues to decrease the loan rate, the price in real terms may decrease with no major effect on WW demand but with a reduction in farm revenue. For example, in case of a shortage of HRW supply due to a drought, the price will increase with no effect on the demand. This is because the demand is WW price insensitive.

A domestic and foreign sales promotion program for WW will stimulate the WW future demand. This promotion should be oriented to better WW uses, a better market positioning, new WW uses, and new products from WW.

It is interesting to ask whether or not the Oregon farmer should shift WW production to HRW production. According to the demand side analysis, the answer is no. The reasons are developed in the following paragraphs.

The first consideration is the potential increase of the WW demand due to an increase of the GNP in the Pacific Rim countries (main importers of WW) and an increase of the rice price (the main WW substitute in the Pacific Rim countries). An increase of 10 percent in the GNP from countries importing WW will yield an increase of the U.S. WW foreign demand by 2.39 percent. Also, an increase of 10 percent in the CIF Japan rice price will yield an increase of 3.82 percent in the U.S. WW demand. These two possibilities (increases in income and rice price) are forecasted by economic experts, such as those of the World Bank.

The second consideration is that the WW price does not affect the WW demand. An increase or decrease in the WW price will not considerably affect the quantity of WW demanded.

The third consideration is the coefficient of the HRW price elasticity, which is inelastic. A decrease of 10 percent in the HRW domestic price will induce an increase of 3.35 percent in the HRW domestic demand, and the WW foreign demand will not be affected. The results will be a sizeable drop in the farm revenue. Oregon, due to its geographical position, would have difficulty in securing the eastern U.S. market, which is the most important one.

The fourth consideration is the trade dependency ratio (ratio between consumption and production) which is an important factor to explain HRW foreign demand. This ratio is expected to decrease and, therefore, the HRW foreign demand will decrease.

For these four main considerations, based on the analysis of the demand for HRW and WW, this research concludes that WW has a better future in Oregon than HRW.

5-5) FURTHER STUDIES

An important research program at OSU (Crop Sciences) would be to find a HRW variety that can compete with WW. The substitution will occur if, and only if, farm revenues per acre are at least as high for HRW as for WW. This is possible if the price of HRW is higher than WW price or if the yield of HRW is higher than WW yield. At present, neither is true, although this situation may change in the future, however additional studies that focus oriented on the farm profit or the HRW and the WW supply are needed.

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APPENDICES

APPENDIX A

U.S. WHEAT CLASSES

Wheat is one of the most important crops in the world. In 1986/1987, the world wheat production reached a record 528.9 million metric tons (USDA). The represented an increase of 27.4 percent, compared to 10 years ago.

During this same time period, wheat use has increased to 519.7 million metric tons, an increase of 37.5 percent.

USSR and China are the two leading production and consumption countries. Paradoxically, they also are the two leading wheat importers.

World wheat trade reached a peak in 1984/1985 (107 million metric tons) and then decreased to 89.8 million metric tons (mt) in 1986/1987. Yet, the quantity traded in 1986/1987 was 42.3 percent higher than that reached 10 years ago.

The U.S. is the leading export country, exporting 31.6 percent of the world wheat trade. After an important increase which ended five years ago, its share in the world market is decreasing. Ten years ago, it was 41.4 percent, which five years ago, it accounted for 49 percent of the world wheat trade.

Three species of what are commercially important:

- Triticum Aestivus (common wheat),
- Triticum Compactum (club wheat), and
- Triticum Durum (durum wheat).

In the U.S., these three species are further divided into five different wheat classes:

- Hard Red Winter Wheat (HRW),

- Hard Red Spring Wheat (HRS),
- Soft Red Winter Wheat (SRW),
- White Wheat (WW), and
- Durum.

Visual characteristics (ie., color, shape and length of the kernel, and the germ shape) determine wheat class. Wheat is further divided into subclasses by color and texture of kernels, such as club and soft wheat for WW.

For reasons to be explained later, this thesis focuses on two different U.S. wheat classes: hard red winter (HRW) wheat and white wheat (WW).

HRW is characterized by a slender and elliptical kernel, a small embryo, a tightly closed crease, a round cheek, and a hard and virtuous endosperm.

WW is characterized by a yellowish white or tannish kernel color, a large embryo and a wide open crease. WW may be hard or soft, spring or winter, common wheat (Triticum Aestivum) or club wheat (Triticum Compactum). Common wheat represents about 90 percent of WW production.

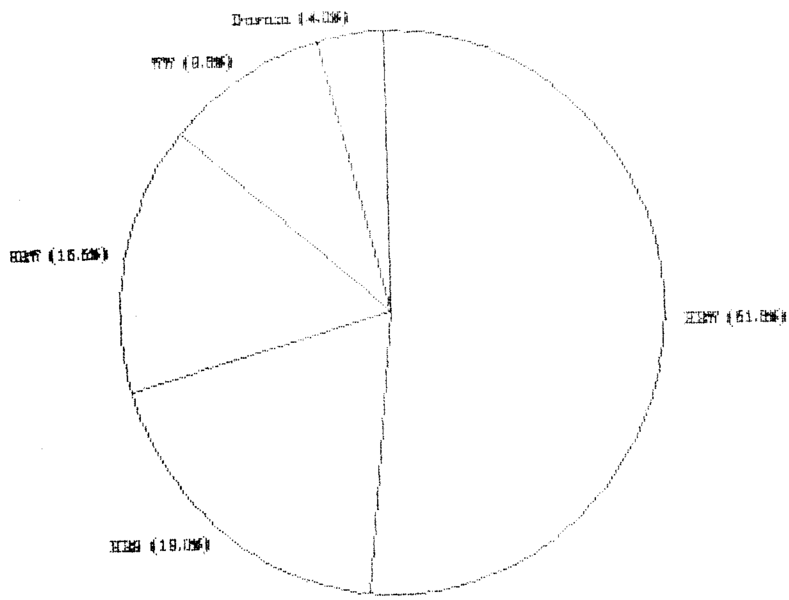
Hard Red Winter Wheat versus White Wheat

Production

HRW is the largest and the most important wheat class in the U.S.. In 1986, it constituted 51 percent of total U.S. wheat production, WW is the fourth largest wheat class constituting 8.8 percent of total U.S. wheat production.

Figure 1

Wheat production by class (1986)

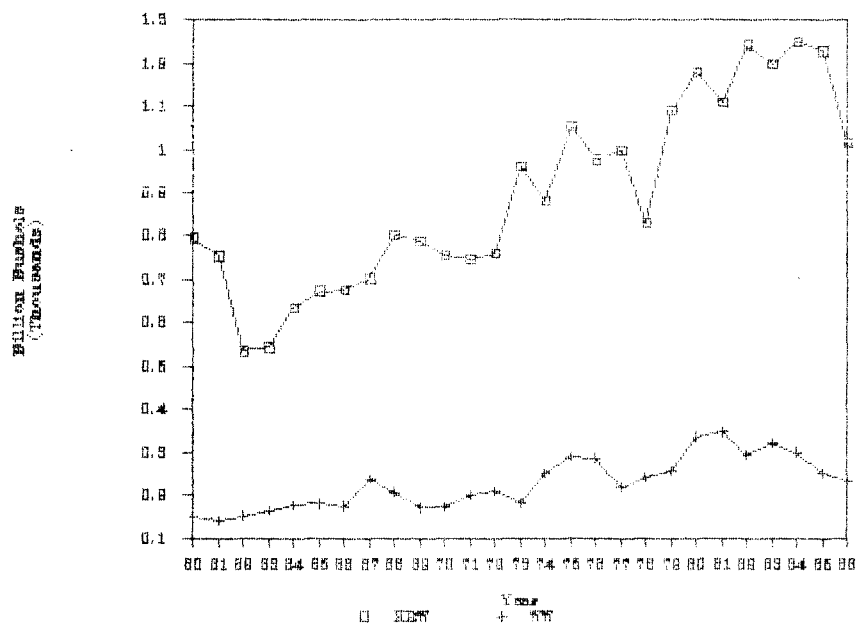


Source: USDA

HRW production is unstable compared to WW production. In 1960, HRW production was high. Then it dropped to its lowest level in 1966, and since then a general increase in HRW production has been reported. WW production, on the other hand, has increased steadily since 1960.

Figure 2

HRW & WW Production (1960-1986)



Source: USDA

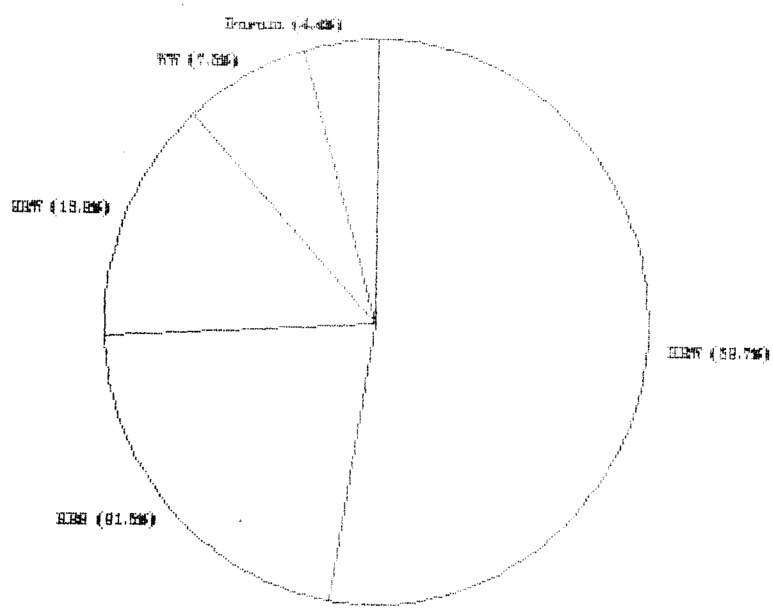
Area of Production:

The heart of HRW production is Kansas. This state accounts for about one-third of HRW production. Oklahoma, Texas, New Mexico, Colorado, Nebraska, Montana, South Dakota, and Missouri also are important producers. In most of the regions where HRW is produced, there is little competition with other wheat classes. This is specially true for Kansas and Oklahoma.

WW is grown in most of western states. The majority of each year's crop comes from the Pacific Northwest (PNW), which includes Washington, Oregon and Idaho. Washington is by far the most important WW state. In 1984, 85 percent of Washington winter wheat production was WW.

Figure 3

Wheat area harvested per class (1986)



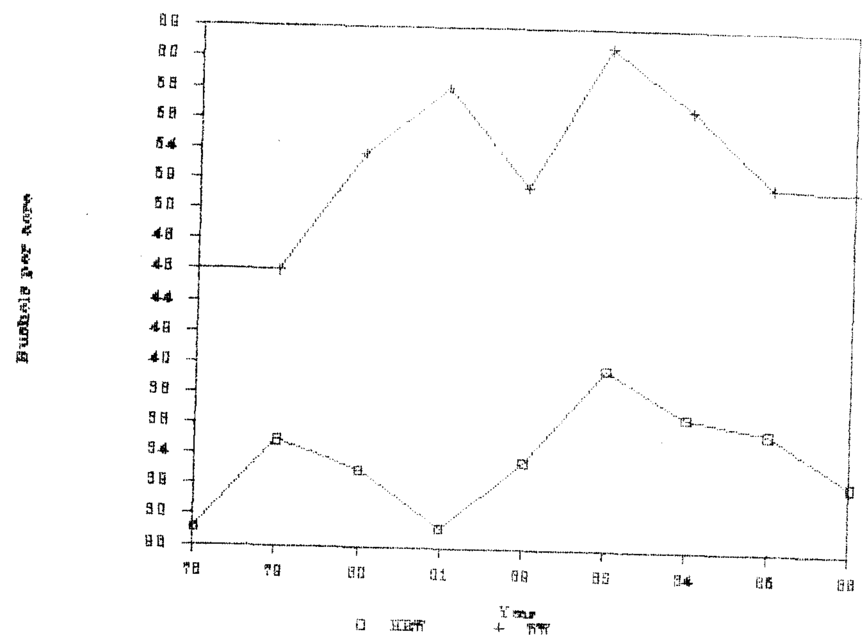
Source: USDA

Yield:

USDA did not publish desegregated wheat yields prior to 1978. HRW, generally, has lower yields than WW. In 1986, WW yields per acre were 59 percent higher than for HRW. The higher yields probably are due to WW varieties, or they could be due to the better potential of the WW production regions. The second hypothesis is defended by Dr. R. Karow, Extension Wheat Specialist at OSU.

Figure 4

HRW & WW yield (1978-1986)



Source: USDA

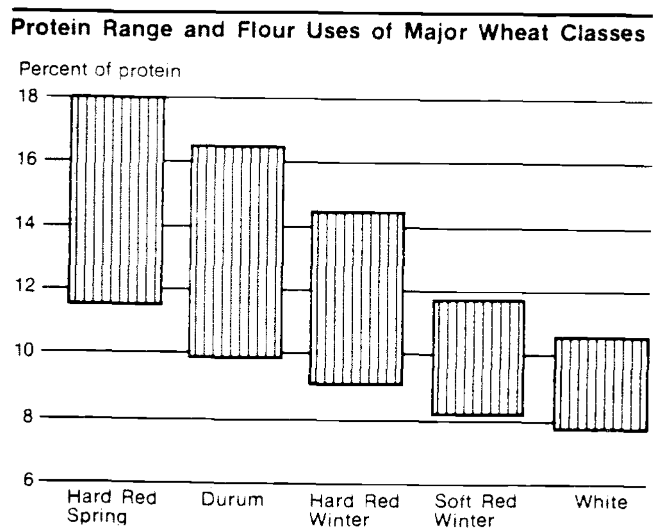
Markets and Uses:

Both domestic and export uses of wheat are important. Domestic uses include flour products, breakfast cereals, livestock feed, seed and industrial uses. Exported wheat is largely in the form of whole grain although lesser volumes of flour and bulgur also are shipped overseas (Grain Marketing Economics).

Each class of wheat has its own distinct milling quality and end use characteristics; protein content is the main characteristic that determines which wheat is used for flour. HRW has a relatively high protein content (between 9.5 percent and 14.5 percent) while WW has a relatively low protein content (between 8 percent and 10.5 percent).

Figure 5

Wheat Protein Content



Source: USDA

HRW can be used for:

- egg noodles (U.S.) such as macaroni and other alimentary pastes,
- bread, bakers rolls, and
- waffles, muffins, quick yeast breads.

WW can be used to make:

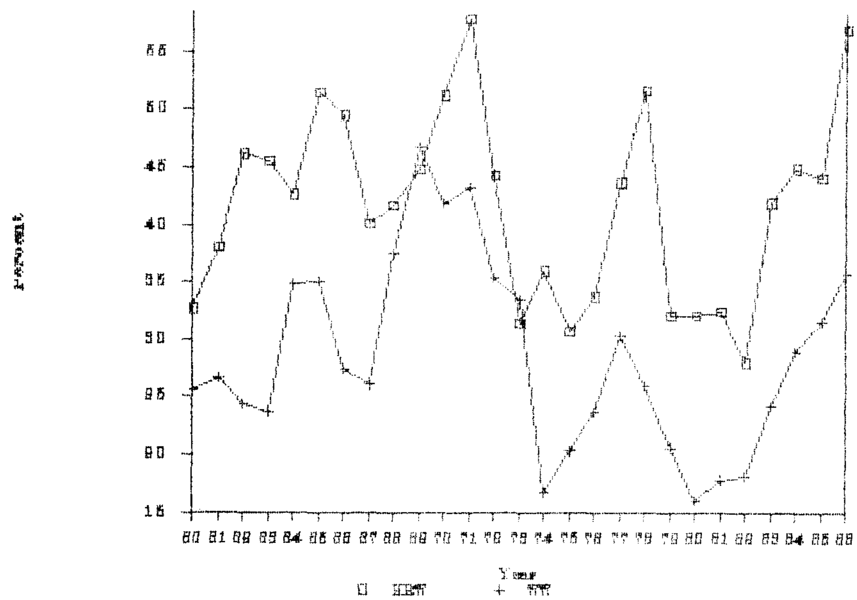
- oriental noodles,
- kitchen cakes and crackers, piecrusts,
- doughnuts and cookies, and
- spongy bread.

Due to different protein contents HRW and WW do not seem to compete with each other. HRS seems to be the main competitor for HRW, while SRW and rice seem to be the major WW competitors (HRW for domestic uses, rice for export markets).

The U.S. wheat market generally gives preference to wheat with high protein content, while Asian markets prefer, for some specific uses, low protein content. Therefore, in Asia, WW has a large market share. However in certain large markets, such as India, there is competition between HRW and WW. In this case, the cheaper wheat is desired.

Figure 6

HRW & WW Domestic Uses/Production (1960-1986)

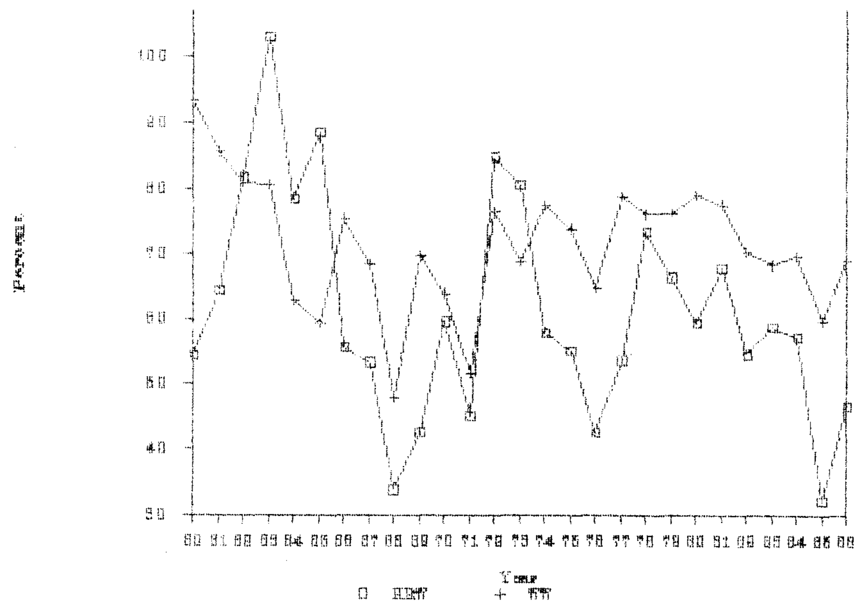


Source: USDA

In 1986, 57 percent of HRW production was used in the U.S. while WW use was 36 percent (Figure 6).

Figure 7

HRW & WW Export/Production (1960-1986)



Source: USDA

In 1986, 47 percent of HRW production was exported while 70 percent of WW was exported (Figure 7).

U.S. WW export market is mainly to the Pacific Rim countries. Japan and South Korea are the two regular major U.S. WW customers. Their share represents about 50 percent of the WW U.S. exports. HRW is exported everywhere in the world including the USSR, EEC, and Japan. Due to its large world market, HRW competes with wheat produced world wide, while WW competes mostly with Australian White Wheat and also with rice consumption in the Pacific Rim countries.

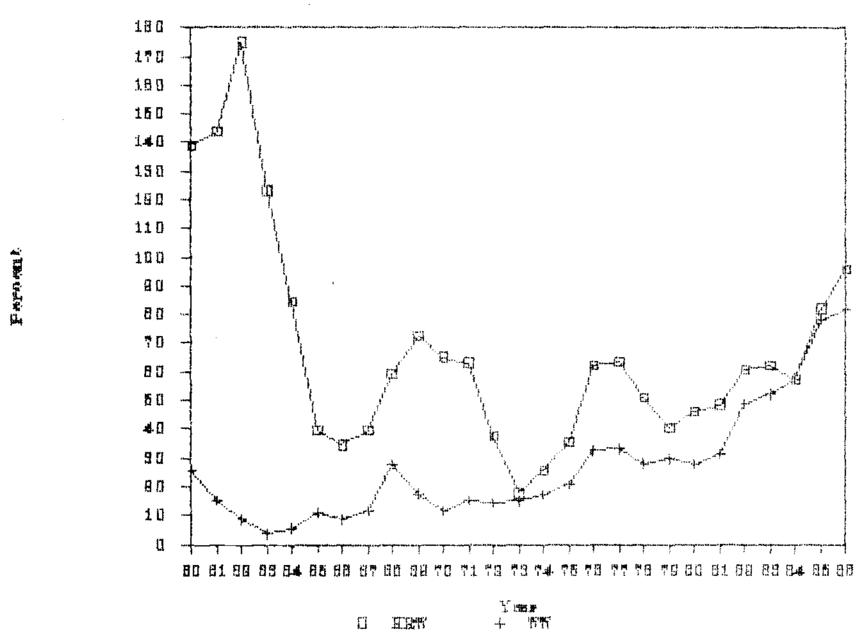
As seen in Figure 6 and 7, the HRW domestic market is very important while the WW market is strongly influenced by Japan and South Korea wheat consumption.

Carry-over:

Wheat carry-over is an important factor in determining wheat prices. HRW and WW carry-over represents almost all their yearly production. In 1986, carry-over represented 96.6 percent of HRW production while the WW proportion was 82 percent.

Figure 8

HRW & WW Carry-Over/Production (1960-1986)



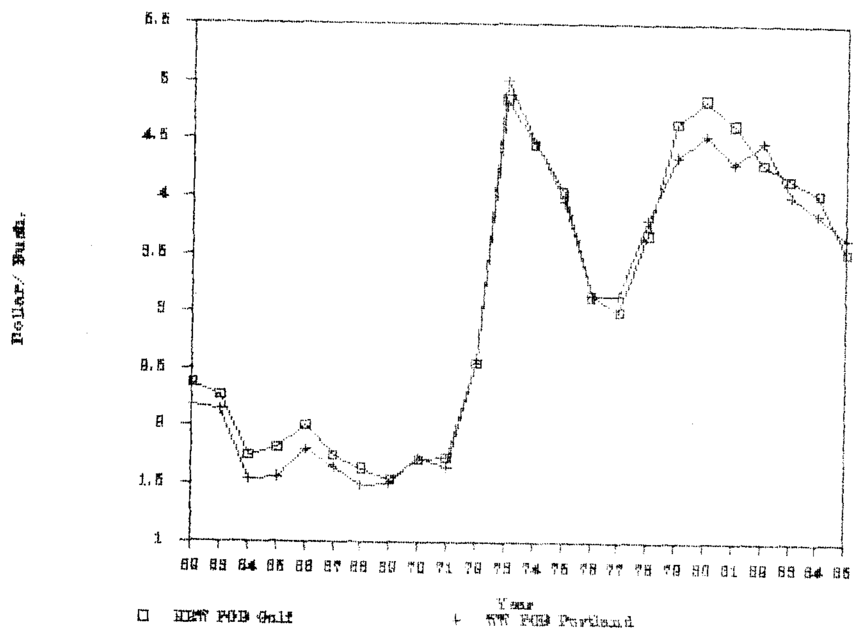
Source: USDA

Price

It is always difficult to directly compare wheat prices. The comparison must be made at the same marketing point, for example, at the farm or at the point of export. The most significant USDA publication of cash prices lists the HRW cash price in Kansas City for HRW and the WW cash price in Portland. Kansas City, Missouri, is in the middle of HRW production region while Portland, Oregon, is an important port for exporting WW.

Figure 9

FOB prices: Gulf for HRW, Portland for WW (1962-1986)



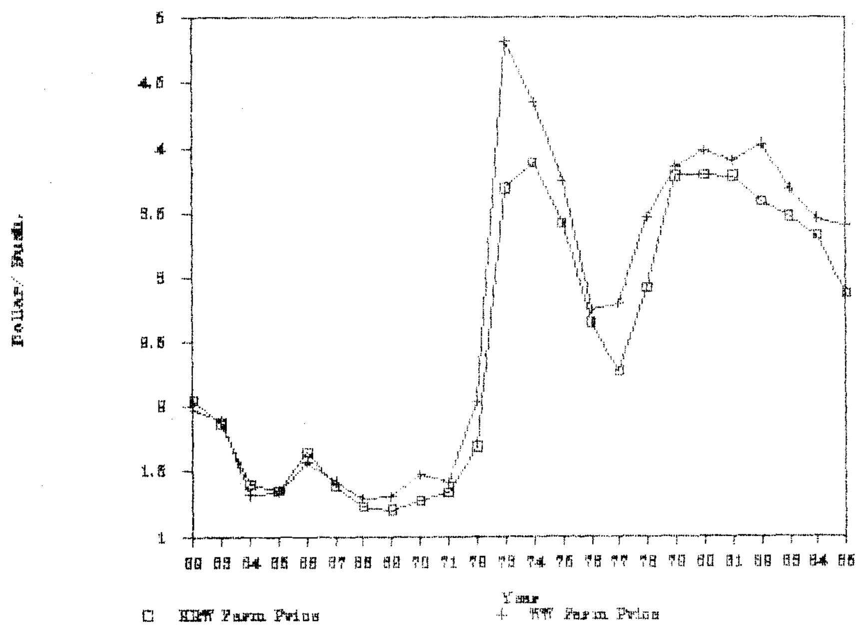
Source: Grain Market News

HRW FOB (Free On Board) Gulf price and WW FOB Portland price are similar and follow the same trend (Figure 9).

The farm price is generally lower for HRW than for WW.

Figure 10

HRW & WW Farm Price (1962-1986)



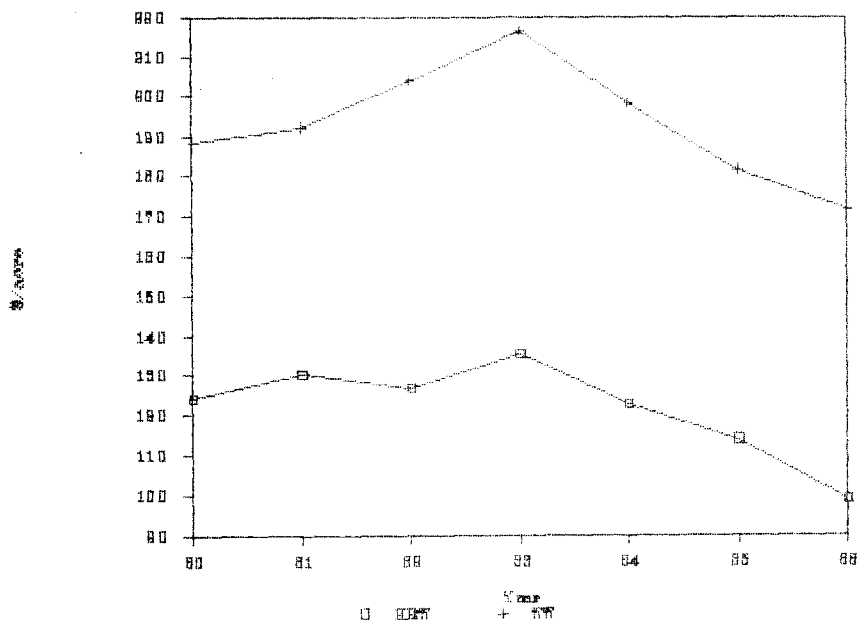
Source: USDA

Cost of Production:

In determining the profitability of growing wheat, production cost becomes an important factor for crop selection by farmers. In 1986, HRW production cost per acre planted represented 58 percent of the WW production cost ($98.94 /acre versus $171.7 /acre). In nominal term, as seen in Figure 11, HRW and WW reached their highest costs in 1983, possibly because of relatively high land values.

Figure 11

HRW & WW Costs of Production Per Acre Planted (1980-1986)

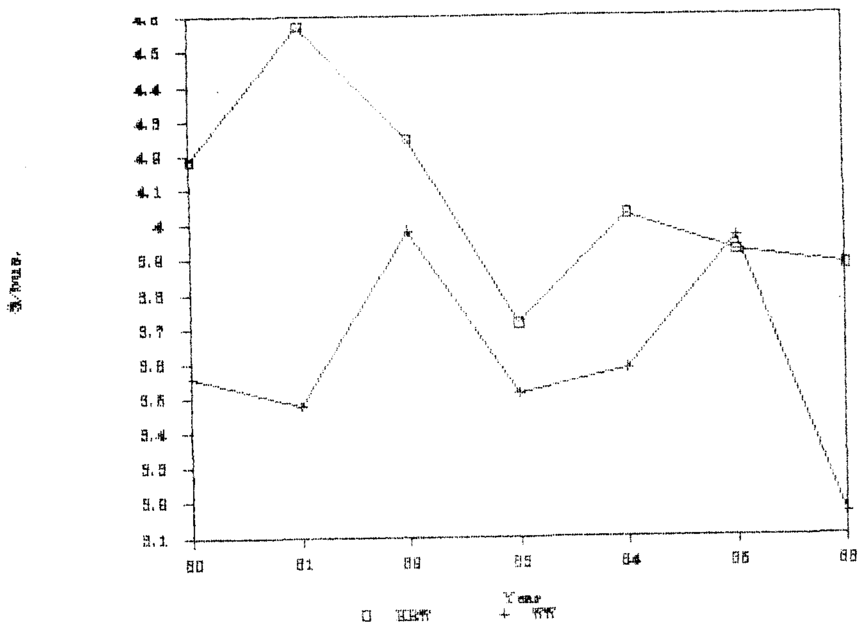


Source: USDA

If the costs of production per bushel produced are compared, the results are different due to the higher WW yields. WW cost of production per bushel is lower than for HRW in all years evaluated except 1985.

Figure 12

HRW & WW Cost of Production Per Bushel (1980-1986)



Source: USDA

APPENDIX B

CHAI'S ESTIMATES OF ELASTICITIES FOR THE U.S.

	HRS	HRW	SRW	WW	Durum
HRS	-1.83	1.53	0.45	-1.36	-0.14
HRW	1.92	-0.73	-0.52	1.65	0.43
SRW	-0.47	0.01	-0.21		
WW	0.50	-0.80		-0.25	
Durum					-1.48
Income	0.52	0.34	0.44	-2.85	-0.96

Estimate based on 1946-63 period

APPENDIX C

HENNING'S ESTIMATES OF ELASTICITIES FOR THE U.S. MODEL

	HRS	HRW	SRW-WW	Durum
HRS	-1.51		0.30	0.41
HRW	1.09	-1.82	1.85	
SRW-WW	0.42	1.45	-2.42	
Durum				-0.36
Income	0.60	-0.28	-0.09	-1.49
Stocks	-1.36	-1.27	-0.72	-0.80
Acreage	0.40	0.18		0.47

estimate based on 1971-80

APPENDIX D

HRW DATA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1962	2.05	2.38	1085	535	247	437	0.3574	317.06
1963	1.87	2.27	936	544	248	562	0.5517	405.68
1964	1.40	1.75	670	635	271	498	0.4691	318.14
1965	1.35	1.82	536	674	347	595	0.6082	614.66
1966	1.65	2.01	268	677	335	377	0.6916	921.15
1967	1.38	1.74	233	703	282	375	0.6644	790.43
1968	1.23	1.63	279	801	334	271	0.6977	1024.76
1969	1.20	1.54	475	789	354	336	0.5864	939.67
1970	1.27	1.71	574	755	387	450	0.6106	1294.78
1971	1.34	1.73	492	748	432	337	0.5722	1273.93
1972	1.68	2.55	505	762	338	644	0.8131	1774.59
1973	3.69	4.85	285	961	301	775	0.5587	1175.44
1974	3.89	4.46	170	883	318	510	0.6012	1276.38
1975	3.42	4.05	225	1055	323	581	0.6379	2236.11
1976	2.65	3.14	376	978	330	418	0.6698	2309.54
1977	2.27	3.00	606	997	436	535	0.5519	2425.02
1978	2.93	3.68	632	830	429	610	0.4864	2344.07
1979	3.79	4.65	423	1092	350	725	0.5045	3126.93
1980	3.80	4.85	440	1181	379	701	0.4698	2949.55
1981	3.79	4.64	541	1112	361	754	0.5772	3247.34
1982	3.59	4.30	538	1243	348	679	0.6437	2296.69
1983	3.47	4.16	754	1198	503	704	0.7069	2246.37
1984	3.33	4.04	745	1251	562	717	0.8436	2448.85
1985	2.87	3.53	717	1230	543	395	1.0000	2592.54
1986			1009					

(1) HRW farm price no deflated ($/bus.)
(2) HRW FOB price Gulf of Mexico no deflated ($/bus.)
(3) HRW stock at the beginning of the crop year (Mill. of bushels)
(4) HRW U.S. production (Mill. of bushels)
(5) HRW domestic uses (Mill. of bushels)
(6) HRW export from U.S. (Mill. of bushels)
(7) HRW exchange rate base 1985 (foreign currency per dollar)
(8) HRW GNP per capita of countries imported U.S. HRW ($)

APPENDIX E

WW DATA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1962	1.97	2.19	21	152	37	123	0.587	31.35
1963	1.89	2.14	13	165	39	133	0.842	43.09
1964	1.32	1.54	6	178	62	112	0.761	40.96
1965	1.34	1.56	10	180	63	107	0.939	36.88
1966	1.57	1.80	20	175	48	132	0.847	72.88
1967	1.42	1.64	15	238	62	163	0.770	80.64
1968	1.29	1.48	28	208	78	100	0.829	121.70
1969	1.30	1.50	58	171	80	119	0.828	117.60
1970	1.48	1.72	30	172	72	110	0.879	103.80
1971	1.41	1.64	20	201	87	104	0.726	97.48
1972	2.04	2.55	55	209	74	160	0.927	113.80
1973	4.82	5.02	30	182	61	125	0.813	105.50
1974	4.35	4.47	27	252	42	195	0.801	139.10
1975	3.75	3.96	43	291	59	215	0.824	145.30
1976	2.75	3.15	60	287	68	186	0.849	233.10
1977	2.80	3.15	93	221	67	174	0.801	214.80
1978	3.47	3.80	73	243	63	185	0.734	198.20
1979	3.86	4.36	68	257	53	196	0.702	214.00
1980	3.98	4.54	76	338	54	267	0.743	2354.00
1981	3.90	4.30	93	348	62	270	0.881	2613.40
1982	4.03	4.49	109	294	53	207	0.918	2685.50
1983	3.69	4.02	143	322	78	220	0.930	2603.80
1984	3.46	3.86	167	301	86	210	0.988	2631.10
1985	3.41	3.66	173	254	79	152	1.000	3586.90
1986			198					

(1) WW farm price no deflated ($/bus.)
(2) WW FOB price Portland no deflated ($/bus.)
(3) WW stock at the beginning of the crop year (Mill. of bushels)
(4) WW U.S. production (Mill. of bushels)
(5) WW domestic uses (Mill. of bushels)
(6) WW export from U.S. (Mill. of bushels)
(7) WW exchange rate base 1985 (Mill. of bushels)
(8) WW GNP per capita of countries imported U.S. WW ($)

APPENDIX F

WHEAT DATA

	(1)	(2)	(3)	(4)	(5)	(6)
1962	8161	248.1	1248.2	307	2.00	133.99
1963	7448	240.0	1427.1	328	1.82	129.41
1964	8653	262.0	1357.6	369	1.30	140.58
1965	8358	281.6	1577.1	260	1.25	167.00
1966	9966	279.8	1454.3	467	1.25	161.76
1967	9425	289.1	1391.2	277	1.25	161.44
1968	10600	306.4	1283.9	544	1.25	185.38
1969	9944	327.3	1367.0	387	1.25	164.39
1970	10175	337.2	1512.9	290	1.25	127.28
1971	11273	344.3	1459.1	316	1.25	88.51
1972	11073	361.8	1933.8	242	1.25	116.67
1973	11992	365.6	1970.4	440	1.25	215.77
1974	11450	366.6	1690.4	417	1.37	526.68
1975	10966	356.3	1898.7	440	1.37	454.75
1976	13326	385.9	1703.9	429	2.25	339.41
1977	12062	399.4	1982.8	344	2.25	200.76
1978	14634	430.2	2031.1	665	2.35	565.01
1979	13429	444.3	2158.3	595	2.50	279.73
1980	13885	445.8	2296.3	400	3.00	315.88
1981	13691	443.6	2617.9	603	3.20	428.37
1982	14778	462.2	2416.9	327	3.55	457.26
1983	15546	482.3	2540.3	808	3.65	214.11
1984	16200	495.0	2577.6	687	3.30	444.75
1985	15901	487.7	1960.0	593	3.30	144.86

(1) Wheat foreign production (Mill. of bushels)
(2) Wheat world consumption including U.S. (Mill. of metric tons, rate of transformation in bushel: 36.76)
(3) Wheat U.S. consumption (Mill. of bushels)
(4) Australian wheat production (Mill. of bushels)
(5) U.S. loan rate ($/bus.)
(6) CIF rice price in Japan ($/MT)

APPENDIX G

ECONOMICAL DATA

	(1)	(2)	(3)	(4)
1962	1656.50	3.26	0.906	186591
1963	1737.30	3.55	0.917	189273
1964	1837.70	3.97	0.929	191830
1965	1911.50	4.38	0.945	194240
1966	2005.00	5.55	0.973	196490
1967	2109.00	5.11	1.000	198630
1968	4326.20	5.89	1.042	200620
1969	4608.80	7.83	1.098	202600
1970	4796.40	7.71	1.163	204880
1971	5151.30	5.11	1.212	207050
1972	5626.00	4.73	1.266	208850
1973	6229.20	8.15	1.331	210410
1974	6702.00	9.84	1.477	211900
1975	7197.10	6.32	1.612	213560
1976	7743.20	5.27	1.705	215140
1977	8750.80	5.61	1.815	216800
1978	9698.50	7.99	1.954	222590
1979	10610.00	10.91	2.175	225060
1980	11590.00	12.29	2.468	227740
1981	12820.00	15.32	2.723	230040
1982	13160.00	11.89	2.891	232350
1983	14080.00	8.88	2.983	234540
1984	15540.00	10.16	3.112	237000
1985	16400.00	8.00	3.222	239280

(1) U.S. GNP per capita ($)
(2) Interest rate
(3) U.S. consumer price index base 1967
(4) U.S. population (Mill.)